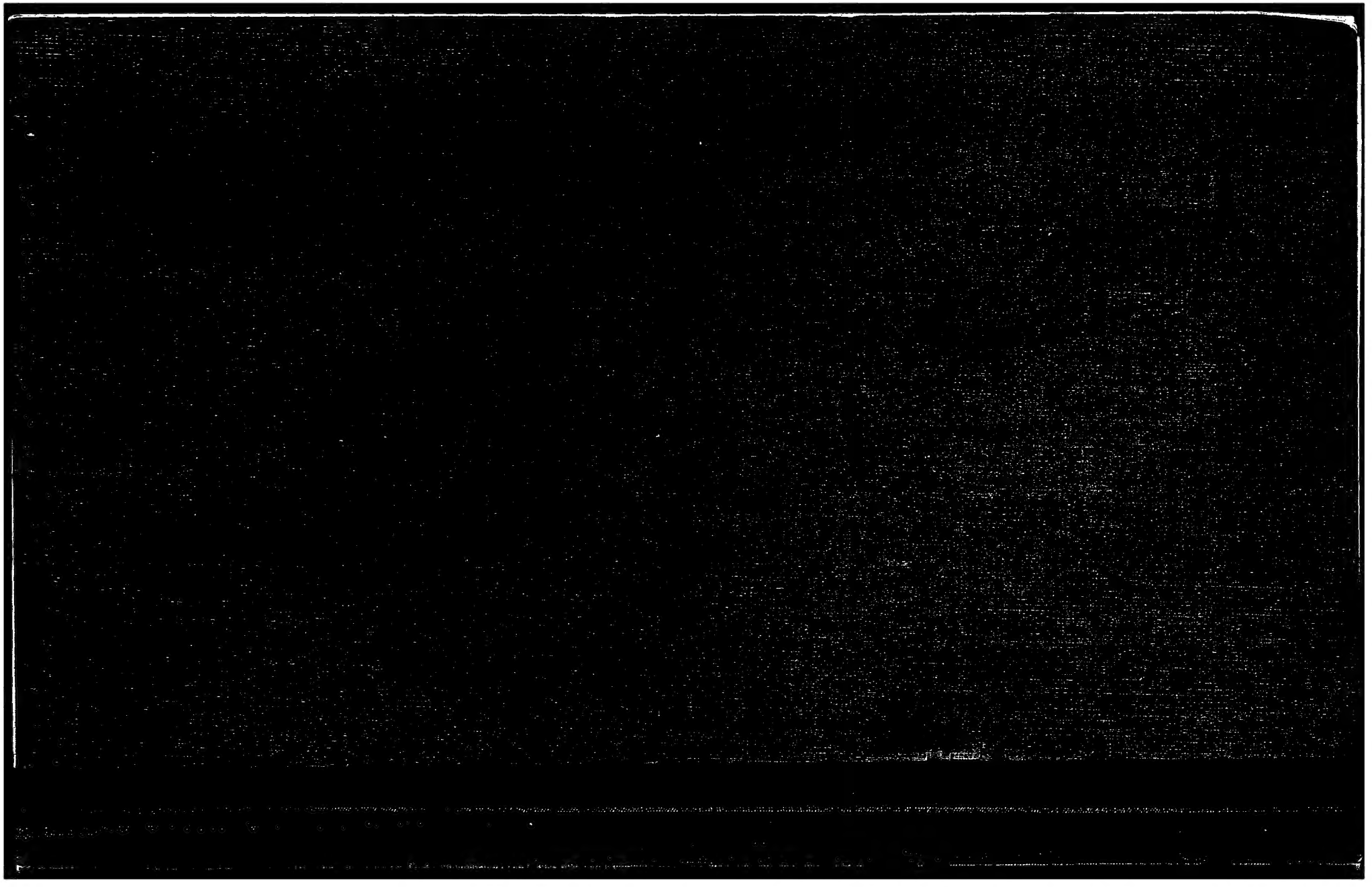


Adapted from an illustration in "Scientific American", June, 1921

F.L.B.

THE HUDSON BAY PORT.

HUDSON BAY.

REPORT

ON THE

SELECTION OF A TERMINAL PORT

FOR

THE HUDSON BAY RAILWAY.

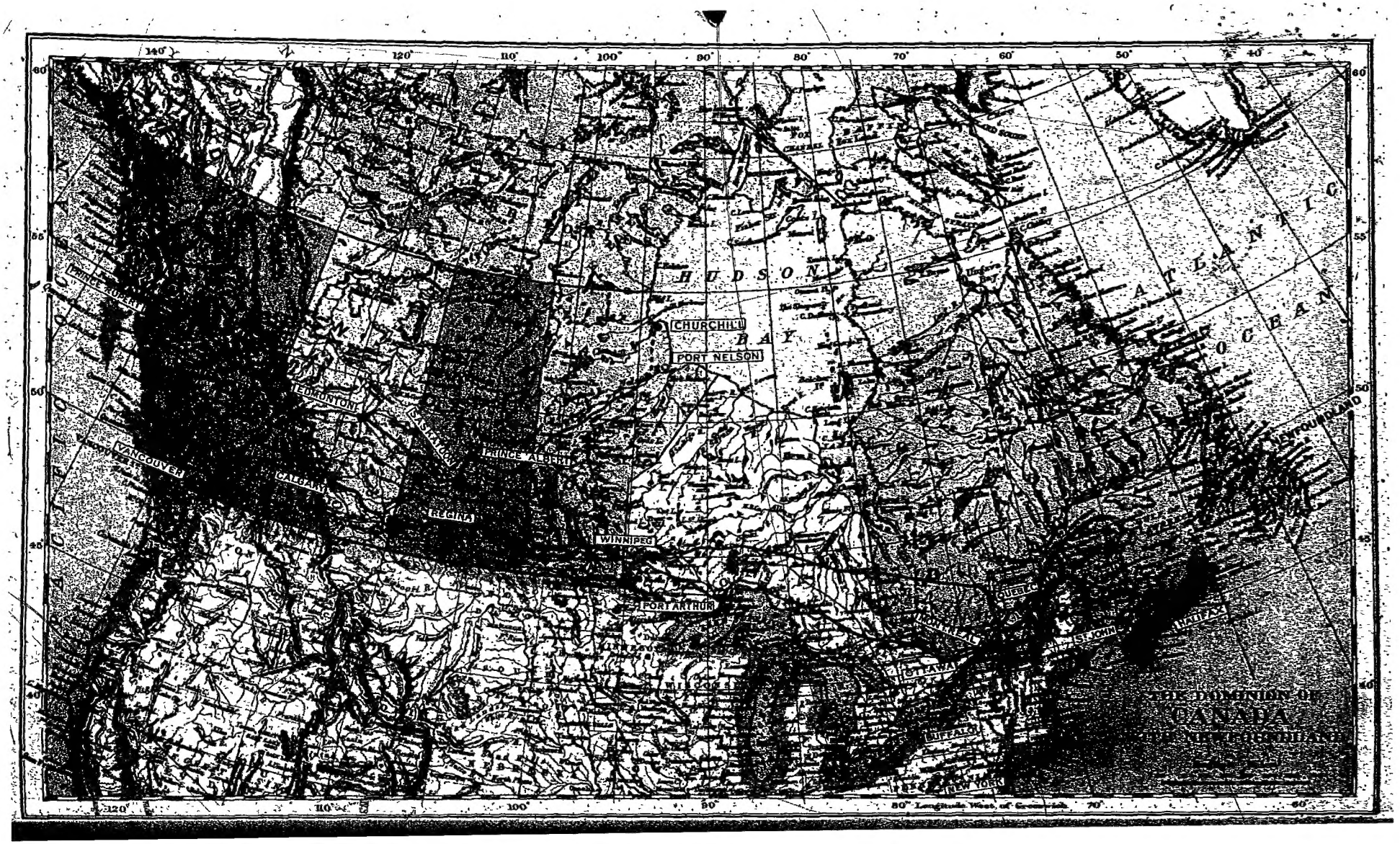
October, 1927.

F. PALMER,
M.Inst.C.E., M.Am.Soc.C.E.,
12–15, Dartmouth Street,
Westminster, London.

CONTENTS.

LIST OF ILLUSTRATIONS.

LIST OF DIAGRAMS AND MAPS.


HUDSON
BAY
ATLANTIC
OCEAN
CHURCHILL
PORT NELSON
EDMONTON
CALGARY
REGINA
WINNIPEG
PORT ARTHUR
VANCOUVER
QUEBEC
MONTREAL
OTTAWA
ST JOHN
HALIFAX
BUFFALO
NEW YORK
NEWFOUNDLAND
THE DOMINION OF
CANADA
140°
120°
110°
100°
90°
80°
70°
60°
50°
40°
60°
55°
50°
45°
40°

REPORT

ON THE

SELECTION OF A TERMINAL PORT

FOR

THE HUDSON BAY RAILWAY.

Introduction.

The references upon which this Report has been prepared are given in the letter, dated 5th January, 1927, from the Hon. Charles A. Dunning, Minister for Railways and Canals, the full text of which is given in Appendix A. The request of the Minister for advice follows upon a Report of a Senate Committee of 1920, which recorded the opinion :— Letter of reference.

> " . . . . that the Government should not make further important " expenditures at this Port " (Nelson) " without first making a " new and thorough examination into the relative merits of Churchill " and Nelson as a terminus for the railroad," Senate Committee's recommendation.

and the main points upon which an opinion is sought are given in the following extracts from the Minister's letter :— Points of reference.

> " In view of the substantial expenditure already incurred at Nelson, " and the shorter rail haul to that point, the Government is naturally " predisposed towards Nelson, but desires, above all things, that the " port chosen, and its arrangements, should afford the best possible " opportunity for the development of trade through the Bay." Government predisposed towards Nelson.
>
> In regard to Churchill . . . . " if a railway is found practicable, " we will require your advice concerning Churchill also. If that " port be found capable of such early and economic development " as would afford better and safer facilities than Nelson, and more " readily available, that would be a factor of great importance." Advice in regard to Churchill.
>
> " In the event of Churchill becoming a possibility, we should " have . . . . relative costs of construction and maintenance . . . . " and comparative estimates of the length of time necessary to " provide terminals at either port " . . . . this latter being . . . . " a matter of prime importance." Relative costs and time.
>
> " We want, also, your opinion of the design of the existing works " at Nelson, and whether any change would " (1) " reduce the cost " . . . . (2) reduce " the length of time required for development, or " (3) " improve conditions . . . . " Opinion on Nelson works.

Initial test development.

" It is suggested for guidance, but not laid down as an instruc-
" tion, that an initial test development would be the provision of
" accommodation in either harbour for six cargo vessels in port at
" one time, with working berths for three of the six, the estimated
" draught of vessels to be not less than 26 feet. The minimum develop-
" ment projected . . . . should . . . be capable of such progressive
" extension as future requirements might dictate."

Capacity for extension.

Recommendation and reasons therefor.

The " report should cover a possible development at both Nelson
" and Churchill, with estimated cost . . . . ; recommendation as
" to the choice to be made and reasons therefor."

Report confined to Port development.

The report . . . " is not intended " . . . to deal with . . . .
" problems unconnected with port development."

INVESTIGATIONS.

Railway to Churchill practicable.

A railway to Churchill from the end of the existing steel having been found to be practicable and no more difficult to construct than to Nelson, it becomes necessary to consider the suitability of Churchill as a Port Terminal and, following upon investigations carried out during the past few months, including test borings made and trial pits excavated at Churchill during the spring of this year, and upon personal inspection of both places, a preliminary report, printed as Appendix B, was submitted on 24th August, 1927, in which it was strongly recommended that Churchill be made the port terminal for the Hudson Bay Railway because it affords by far the best possible opportunity for the development of trade through the Bay.

Preliminary report submitted.

CONCLUSIONS GIVEN IN PRELIMINARY REPORT.

The conclusions upon which this recommendation was made were given in the preliminary report and are as follows:—

Churchill recommended.

1. That Churchill is undoubtedly the Port to be selected as affording a real harbour in which shipping facilities can be provided in calm water protected from all storms by the surrounding rocky cliffs.

Capital cost much less at Churchill.

2. The estimated costs of corresponding accommodation at Nelson and Churchill disclose marked advantage in favour of the latter, the figures showing that, including interest during the period of construction, the cost at Churchill will be less than one-third of what is required to complete Nelson. Even after adding the cost of the extra 87 miles of railway to Churchill, the cost at this place will be only about one-half of the Nelson Port estimate.

Construction time less at Churchill.

3. The time for completion of the works at Churchill, viz., three years, is one-half of the time needed to carry out the Nelson works.

Churchill sheltered; Nelson exposed.

4. That Churchill provides a completely sheltered port for shipping from the moment the entrance is passed, while at Nelson no shelter can be confidently reckoned upon until the wharf is reached, and then only by the provision of breakwaters.

Annual charges less at Churchill.

5. That the annual charges, including interest, operation and maintenance, would be about a million dollars greater at Nelson than at Churchill.

6. That at both Nelson and Churchill the sites admit of considerable extensions, but at much less cost at Churchill than at Nelson. The wharf, either in its initial or extended stage, would at Nelson be governed by the limiting nature of its approach, and would be restricted to vessels of 26 feet draught during a brief period around high water at neap tides, unless much increased expenditure is incurred in dredging. It is limited to a draught of 28 feet even after this dredging is done, unless still further expenditure of a prohibitive character is undertaken.

Ample room at both Ports.

Limitation of draught at Nelson.

7. The evidence regarding ice conditions at both ports is vague and inconclusive, and no satisfactory or reliable decision can be given in regard thereto. It has been stated that the river at Churchill freezes over earlier than the Nelson River and, also, that Bay ice blocks the entrance to Nelson for a later period than that over which Churchill entrance is closed; but in the absence of any evidence dealing directly with the navigation aspect of the question it is impossible to say that either port is open to ocean-going steamers for a longer or shorter period than the other.

Ice conditions.

Full Report.

The preliminary report having only briefly outlined the results of the investigations made and the reasons for conclusions reached, this full report is now presented.

Herein it is proposed :—

I. First, to amplify the general description already given in the preliminary report of both Nelson and Churchill.

II. Then, to set out in detail the reasons leading to the various conclusions, taking them in order (the first and fourth together, for convenience) thus :—

1 & 4	...	Physical conditions.
2	...	Capital cost.
3	...	Time for completion.
5	...	Annual charges.
6	...	Room for expansion.
7	...	Ice conditions.

III. Lastly, to show in a table of comparison the main factors relating to both ports.

Upon these particulars the recommendation is based that Churchill should be adopted.

The plans upon which estimates have been prepared are included at the end of the report.

I.—General Description.

NELSON.

The river.

The roadstead of Port Nelson is situated in the estuary of the River Nelson. The river debouches from the northern end of Lake Winnipeg at Norway House. As this lake receives the waters of both the North and South Saskatchewan Rivers through Cedar Lake by way of Grand Rapids, the Nelson River may be said to receive the drainage of southern Saskatchewan, and of Alberta south of Edmonton to the Rocky Mountains, the total length of the area drained approaching 1,500 miles. On the Saskatchewan River there are two or three small lakes west of Winnipegosis, and between Norway House and the Bay there are many small lakes through which the Nelson flows.

Lower reaches of river.

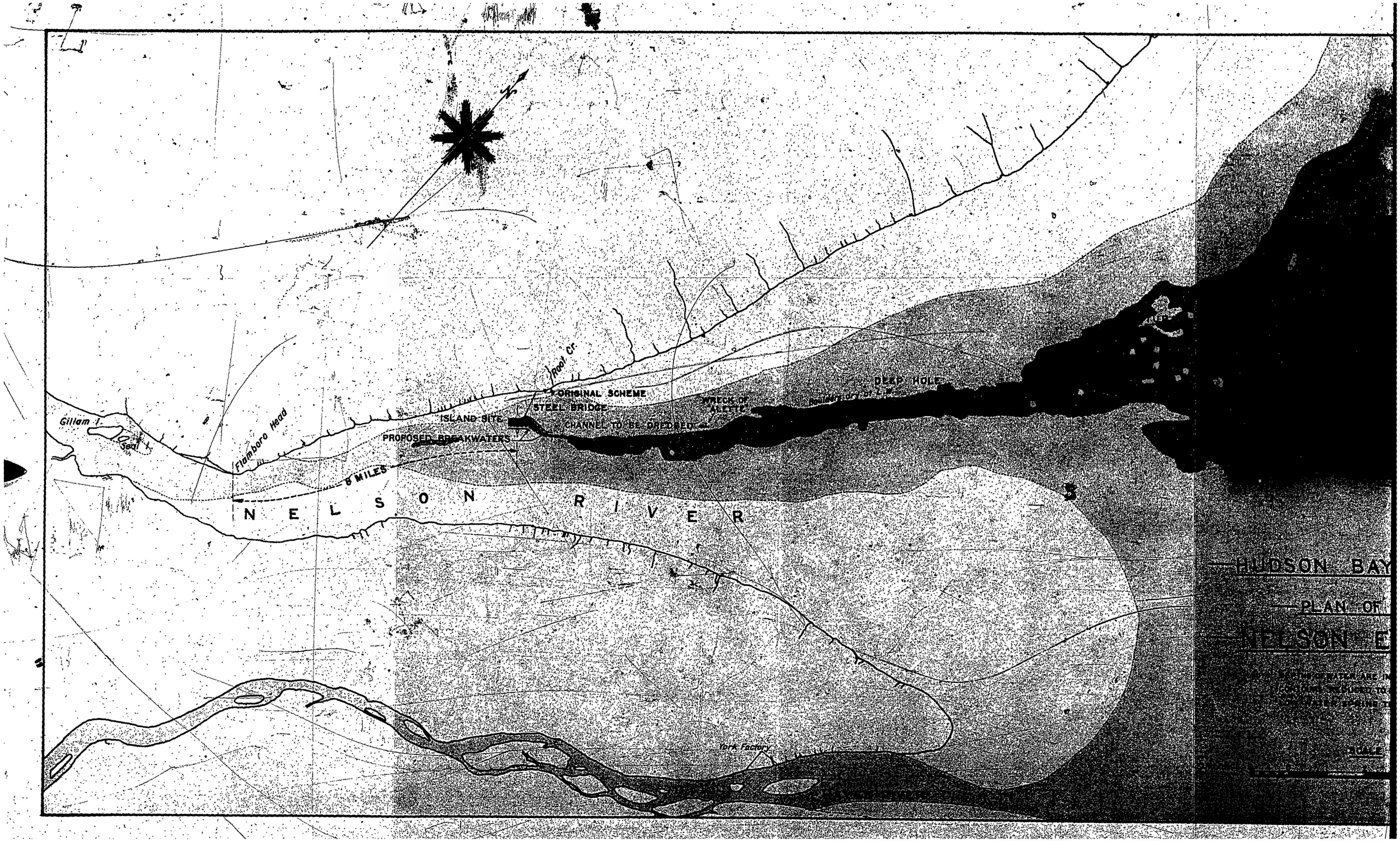
Along that part of the river which was seen on the recent visit of inspection, that is, at Kettle Rapids and from Limestone Rapids to the sea, the banks are high and steep, covered with small spruce, and the river is wide and winding in its course, with several rapids in the first forty miles, and many islands and shoals. The channel from the "Head of Navigation" (below the worst rapids) was, in August last, only sufficiently deep throughout to allow the passage of 3-feet draught boats.

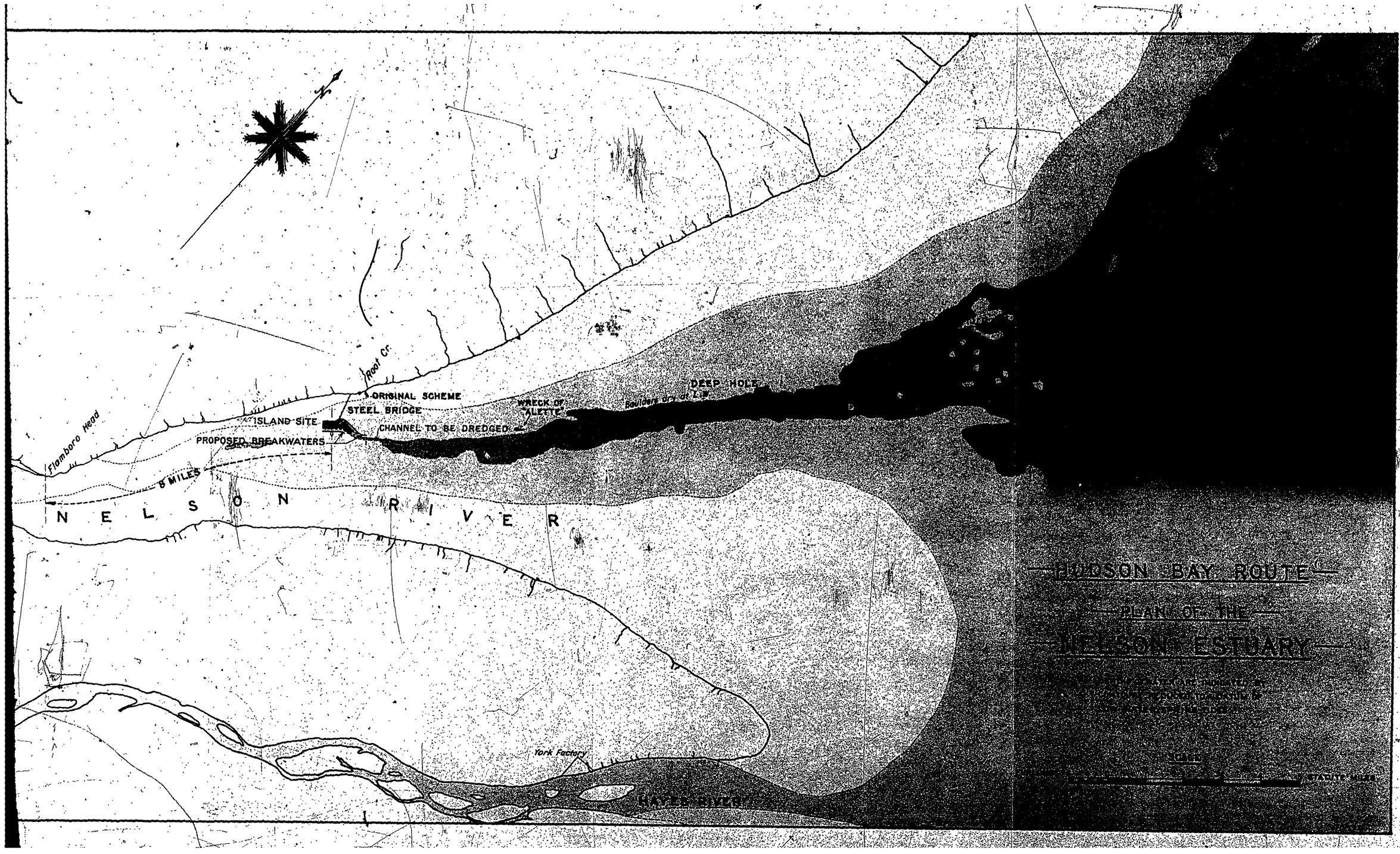
The estuary.

Flamboro' Head, nearly 30 miles up the river from the 30-feet contour in the Bay, may be described as being the commencement of the estuary, but tidal waters extend to Seal Island, 3½ miles farther up. The shores of the estuary fall away from high banks of stiff clay and earth at Flamboro' Head to shores only 4 feet above high water at Root Creek, the site of the

Kettle Rapids, Nelson River.

Harbour works, 8 miles below Flamboro' Head. At this point the river is 4 miles wide, with the channel over a mile from the west shore. Farther down, the shores become still lower, until, at the mouth of the estuary, they are only about 2 feet above high water, and the low-water mark is no less than 4 to 6 miles from the shore, with a total width between the

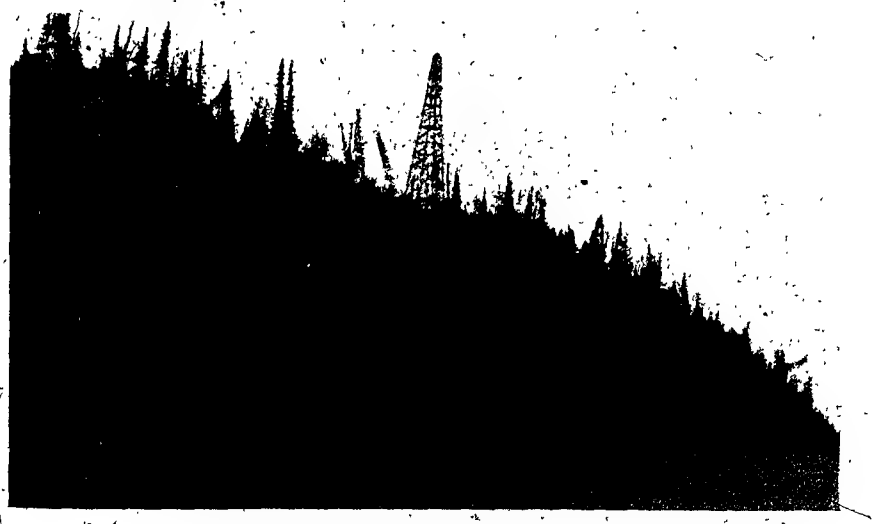

Gillam I.
Seal I.
Flamboro Head
Root Cr.
ORIGINAL SCHEME
STEEL BRIDGE
ISLAND SITE
PROPOSED BREAKWATERS
CHANNEL TO BE DREDGED
WRECKS OF
DEEP HOLE
8 MILES
N E L S O N R I V E R
York Factory
HUDSON BAY
PLAN OF
NELSON E


Flamboro Head
Root Cr.
ORIGINAL SCHEME
STEEL BRIDGE
ISLAND SITE
CHANNEL TO BE DREDGED
PROPOSED BREAKWATERS
WRECK OF "ALETTE"
Boulders dr. at L.W.
DEEP HOLE
5 MILES
N E L S O N R I V E R
York Factory
HAYES RIVER
HUDSON BAY ROUTE
PLAN OF THE
NELSON ESTUARY
STATUTE MILES

shores of 15 miles. The rise of tide at the outer end of the outer shoal is, at spring tides, 17 feet above low-water level of spring tides, while neap tides rise to 13½ feet. At Root Creek the range varies from 15 feet at spring tides to 10½ feet at neap tides, and high water is 40 minutes later at this point than at the outer shoal 19 miles lower down. Tidal range.

Typical steep banks, 100 feet high, at lower Limestone Rapids.

The approach from the Bay to the estuary enters into shallow water far from sight of land, and, during the period when the existing works were Approach from Bay.



Flamboro' Head, with temporary beacon.

under construction, high beacons were erected, at distances of from 10 to 29 miles from the entrance, to guide vessels to the port. These great distances indicate the extent of the estuarial area of shallow waters with flat and marshy shores, and the beacons were, of course, of little use in times of even light mists. Estuary shallow.

Aerial view of the estuary at Port Nelson, showing Seal Island and the works already constructed. The estuary, commencing with a width of 1¼ miles at Flamboro' Head, continues to widen out to the Bay.

The roadstead for ocean-going ships is a deep channel known as the "Deep Hole," which commences about 9 miles above the entrance and extends upwards for a distance of 5½ miles; from the upper end of the "Deep Hole" to Flamboro' Head there is a fairly well defined channel, with depths varying from 18 to 4 feet at low water, with extensive shallows on either side. The outer shoal below the "Deep Hole" is crossed by an irregular channel, which was discovered during the construction period, over which the limiting depth is 20½ feet. It is highly improbable that this channel will be improved by nature, but quite possible that it may become worse by silting in such a wide and shallow estuary.

The "Deep Hole."

Outer shoal.

Vessels entering from the Bay, before the erection of beacons during the construction period, had considerable difficulty in discovering the entrance channel, and could only attempt to do so at times of high water. The best channel then known had a governing low-water depth of 18 feet and led to the "Deep Hole," around the sides and ends of which was the anchorage ground. Above this place there were no depths greater than 20 feet in which vessels might anchor. There was, moreover, no protection against storms, excepting the shoals at the entrance to and within the estuary, and, even in moderate gales, safety was by no means assured. After the beacons were placed in position, it was not so difficult to make the entrance channel in clear weather, but, on occasions of light mists, the beacons are not visible. This was the case on the return journey from Churchill on 7th August last, when the tug "George W. Yates," drawing only 10 feet, was obliged to anchor off the entrance until a slight haze lifted, and, even then, struck lightly a boulder or other obstruction on the way in.

Entrance channels.

No protection against storms.

Such is the channel approaching Port Nelson, and, with strong river and tidal currents to contend with and exposed to all weathers, the approach to Port Nelson can only be described as a constant menace to shipping. The least departure from the strictest vigilance and care on the part of those responsible for navigation would result in losses that would prejudice the port to a far greater extent than the intrinsic value of losses sustained. Port Nelson is merely a roadstead in the estuary, and it is in particular exposed to north-east gales, which occur at somewhat frequent intervals during the period of navigation.

Navigation difficult.

Exposed roadstead.

The tidal range of 17 feet at the outer shoal and 15 feet at the Island Wharf site is the factor which makes the estuary navigable for vessels of more than 15 feet draught. It is the fact that there is a distance of 22 miles from deep water in the bay to the site of the deep water of the wharf basin—22 miles of which all but 5½ miles is over shoals—that constitutes the difficulty of navigating the approach to the wharf from the Bay. And that distance, which means 2½ hours' steaming, and the 40 minutes difference in the time of high water between the two places named, necessarily involve corresponding difference in the depth of water available at the end of the journey as compared with the depth at the time the journey of 22 miles was commenced. For instance, a vessel leaving the wharf at the time of high water would have to cross the outer shoal 2½ hours later. Add to this the difference, 40 minutes, in time of

Effects of tide.

Time and tide wait for no man.

tide, and it will be seen that the tidal rise over the outer end of this shoal would be decreased to the extent to which 3 hours and 20 minutes affects the fall of tide, viz., to practically half-tide.

Tidal rivers. The fact that a river is tidal is, generally speaking, in its favour, in that the rise of tide makes that river navigable twice a day for deeper draught vessels than would otherwise be possible. Both Nelson and Churchill are tidal waters but, in the case of Nelson, there are natural low-water depths of about 20 feet at the outer shoal, whereas, at Churchill, there is no natural low-water depth of less than 33 feet between the bay and the sheltered area inside the headlands, and it is this 13 feet or so of greater depth which makes all the difference to the navigability of the respective entrances.

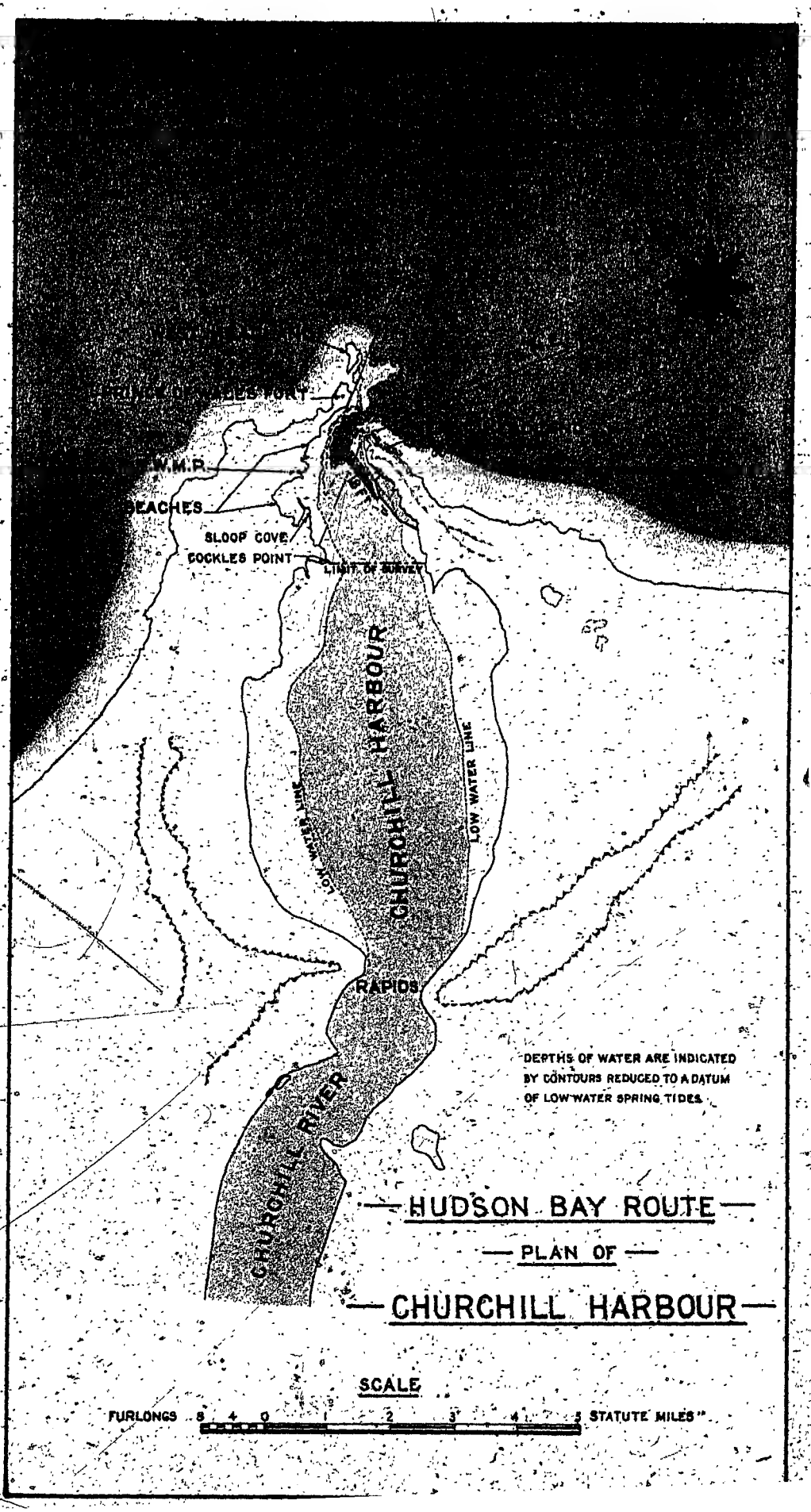
CHURCHILL.

The river. The harbour at Churchill is at the mouth of the Churchill River, which takes its rise in Lake Ile à la Crosse in East Saskatchewan, and as this lake is the outlet for the Beaver River rising in Alberta, a hundred miles or so north of Edmonton, it may be said that the Churchill River carries to Hudson Bay the drainage from a territory nearly 1,000 miles in length, passing in its course through several large and small lakes. **Outlet to Bay.** The outlet to the Bay is through a passage between rocky headlands, and as the width of this passage at low water is so narrow—in fact no more than is necessary for a convenient Harbour—the considerable and useful entrance depth to which the river maintains its bed in this gateway can be understood.

The harbour. The harbour inside the headlands is about 6 miles in length, the low-water width increasing from the entrance to about a mile at Cockles Point, 1½ miles inland, and to about 2½ miles farther up. **Harbour depths.** The low-water depths in the harbour are upwards of 30 feet over a width varying from 1,800 to 800 feet for a length of a mile on the western side, and along the eastern side an arm of water, 24 feet deep, is found for a distance of one mile, while the 18-feet depth contour extends inwards on the eastern side as far as 2 miles from the entrance. A survey of the harbour was made in 1910 over a distance of about 2½ miles from the entrance. Beyond this point, to the limit of tidal waters, the depth probably decreases to about 10 or 12 feet below low water in the channel, with shallow water on either side.

Water area. The total area of tidal waters inside the entrance may be in the neighbourhood of 15 square miles at low water, but as no surveys exist of the whole harbour, this area is only roughly approximate.

Harbour naturally protected. The configuration of the narrow entrance admits no storms into the harbour excepting those from between north-north-east and east-north-east, and as the general axis of the enclosed water is slightly east of south, such storms spend their waves on the north end of the west shore. There are two small bays on this shore, north of Sloop Cove, which are obviously the "spending beaches" for such storm-waves as may be able to pass between the headlands. Beyond these two bays there is practically no wave effect, even on the west side, while the eastern side affords calm water at all times.

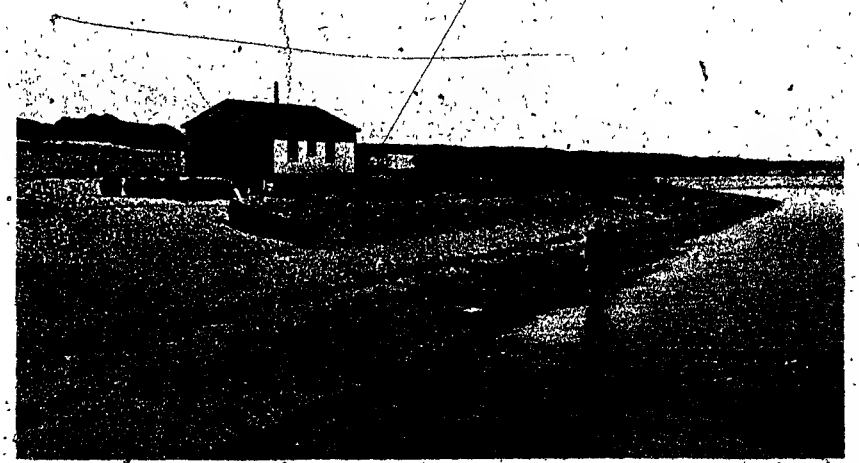

M.M.P.
BEACHES
SLOOP COVE
COCKLES POINT
LIMIT OF SURVEY
CHURCHILL HARBOUR
LOW WATER LINE
LOW WATER LINE
RAPIDS
CHURCHILL RIVER
DEPTHS OF WATER ARE INDICATED BY CONTOURS REDUCED TO A DATUM OF LOW WATER SPRING TIDES.
HUDSON BAY ROUTE
PLAN OF
CHURCHILL HARBOUR
SCALE
FURLONGS 8 4 0 1 2 3 4 5 STATUTE MILES

During a northerly storm—the only direction from which high winds affect the harbour—on 6th August, 1927, the following photographs were taken to illustrate conditions inside and outside the harbour.

Stormy sea outside Churchill (6-ft. waves), wind N.E.

Entering from the Bay, vessels of 30 feet and less in draught would approach in a south-westerly direction, heading for the R.N.W.M. Police Barracks, which show up very prominently from the open sea, where a least depth of 33 feet at low water is found about three-fourths of a mile from the

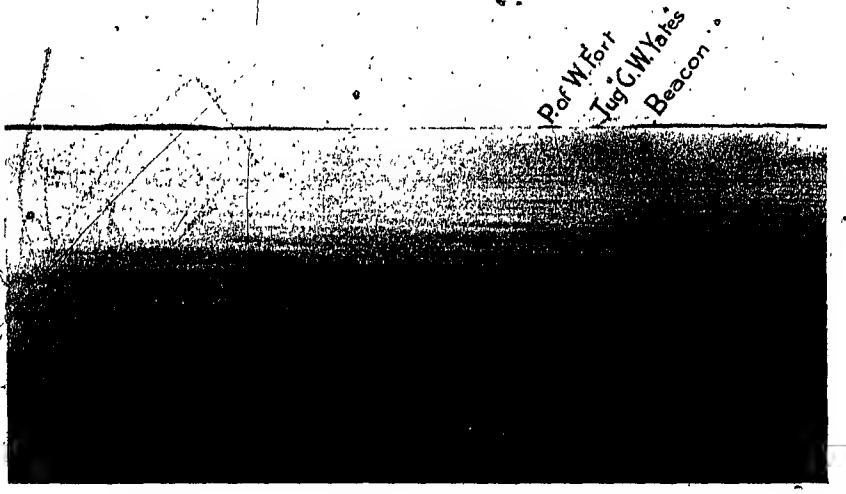
Entrance from Bay.



Smooth water along east side of Churchill Harbour (proposed site of Wharf) during the same storm.

headlands forming the breakwaters, gradually deepening to 80 and 90 feet in the passage between the cliffs. These headlands and the barracks are clearly visible from some miles out at sea, and therefore the entrance is easily made. The deep water inclines to the south, and for over ¾ mile there is more than 30 feet depth of water at low water.

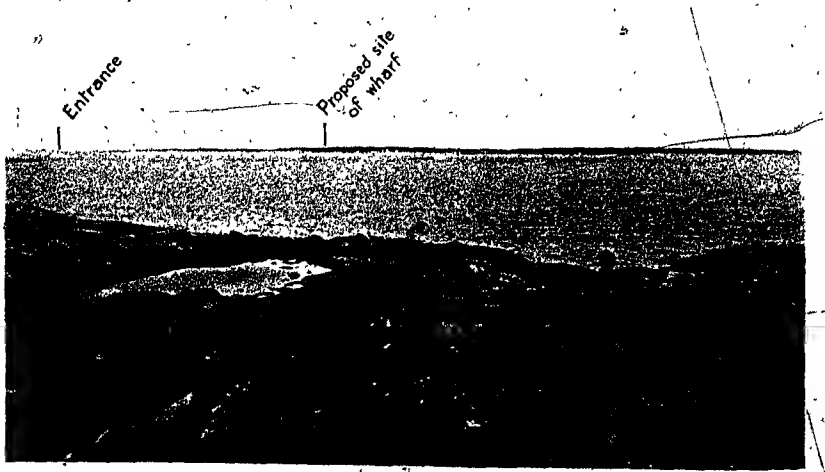
Vessels exceeding 30 feet in draught would approach the entrance in a W.S.W. direction until the headlands are reached and then turn south-west along the line indicated for lesser draught vessels. The least depth in the Bay on this course is 39 feet below low water half-a-mile out.



View from a boat in Churchill Harbour looking towards the entrance 3½ miles away. Tug "George W. Yates" in the entrance between Prince of Wales Fort and Beacon.

Admits of deep draught.

It is seen, therefore, that vessels up to 35 feet draught can enter the harbour at all states of the tide, and Churchill, apart from ice conditions, can well be described as a harbour attractive to shipping because of the easy entrance, good anchorage inside for three or four vessels up to 30 feet in



Deeper portion of Churchill Harbour from Sloop Cove.

draught and as many more of 24 feet draught, with absolute protection from storms.

With the foregoing general description of both ports, the reasons leading to the conclusions enumerated on page 6 can now be given.

II.—Reasons for Conclusions given in Preliminary Report.

CONCLUSIONS 1 AND 4—(PHYSICAL CONDITIONS).

NELSON.

Constructional difficulties.

The difficulties inherent to navigation from the open sea to the roadstead at Nelson have already been mentioned. The difficulties attending the construction of a safe harbour are at least equally great, as shown by the experience obtained in carrying out the works which now exist. The design for wharves, for which plant was collected and upon which work was carried out in 1913 and 1914, was found to be quite impracticable, and it was only after Mr. McLachlan had taken charge in August, 1913, and had spent the remainder of that season and the working season of 1914 in abortive attempts at carrying out this design, that he conceived the idea and worked out proposals for the island wharf, which was adopted early in 1915.

Earlier efforts.

His plans included an artificial island about 4,000 feet long, placed parallel to the west shore and ¾ mile distant therefrom, connected with the mainland by a bridge, designed to carry a single line of railway.

Island site.

The position chosen for the outer side of the island was in a depth of only 2 feet at low water, but the "hard-pan" bed of the river here began to shelve somewhat steeply, and the working wharf was intended to be placed outside at a distance of 120 feet, where a low-water depth of 30 feet was obtainable by dredging, mainly in mud, but with some amount of "hard-pan" excavation. The girders of the bridge connecting the island to the shore are of steel. There are 17 spans of 140 feet, carried on piers consisting of large cribs in which timber piles were driven to support the steel girder superstructure. The cribs are filled with boulders and gravel, and, as protection from erosion of the river bed on which they were founded, they were surrounded by boulders and heavy stone collected from the river side in the neighbourhood of Flamboro' Head. The island, which is 400 feet wide, therefore formed the site from which the permanent wharf was to be built and upon which the dock facilities, transit sheds, grain elevators, railway lines, etc., were to be constructed, and it may be mentioned here that both the site selected and the method proposed for providing a wharf afford as satisfactory a scheme as could be devised in this river.

Bridge approach.

Final scheme.

Deterioration of works.

Nothing of a permanent nature exists to-day beyond the bridge superstructure. The crib piers and the piles carrying the girders already show signs of decay, and it would be necessary to replace these by permanent piers of concrete. The timber cribwork, which has so far been built to form the island, has also deteriorated during the past ten years, and can only have remaining a comparatively short life. This last-named decay is,

View of the attempt to run out a solid jetty from the shore at Nelson, causing rapid silting on either side and excessive scour at the end.

however, not of vital importance, because the permanent wharf would uphold the outer side of the island, while the ends and back could be adequately protected by rock pitching.

The cribwork of the "island" at Nelson and the approach bridge.

Existing channels.

Some general remarks have already been made about the approach from the Bay (see p. 9). The contour line of 30 feet depth at low water is about 22 miles from the island. From mile 19 to mile 13½ (5½ miles) an irregular shoal exists over which the present governing depth is 20½ feet at

The inside of the island from the outer cribwork. Tug "George W. Yates" on the outside of cribwork.

low water. From mile 13 to mile 7½ there is the "Deep Hole," in which the depths vary from 24 to 94 feet at low water, and from the upper end of this Hole, at mile 7½, to the downstream end of the wharf there is a channel with depths of 18 feet and more at low water for a distance of 4 miles, and thence

it is necessary to form an entirely new channel through depths varying from 18 feet at low water at the lower end to about 2 feet at the wharf. The proposed channel, to give a depth of 20 feet at low water over the proposed

Rough water experienced at the island site at Nelson during a N.E. breeze, 6th October, 1917.

Extensive dredging necessary.

width of 300 feet, would therefore entail dredging over 7 miles. At the wharf it was intended to dredge a basin 30 feet deep at low water, so that vessels might lie afloat at all stages of the tide, and, in order to minimise maintenance dredging in this basin, a course was to be dredged above the

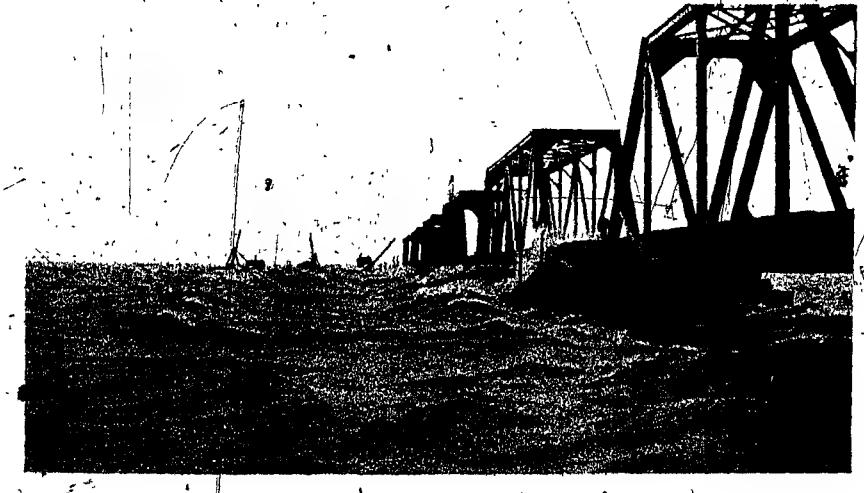
Big sea, Crib-end Wharf 3 at Nelson, 14th September, 1916. Wind N.W.

wharf to divert the main channel of the river in this direction. Of the total dredging required, a large quantity in all, only an infinitesimal amount had been done.

The engineer in charge had always realised that breakwaters would be necessary to protect vessels at the wharf from the heavy swell which arises, even with storms having a wind velocity very little over 20 miles per hour, which occur frequently during the navigation season, but no definite plan had been worked out. For storms of greater intensity, and these occur not infrequently, it is, of course, still more necessary to have adequate protection. The best plan for ensuring the necessary comparatively still water at all times within the wharf basin would seem to be the construction of a rock breakwater parallel to the wharf and 750 feet away, extending downstream beyond the basin and flanked by a second rock breakwater taking off from the north end of the wharf, forming a turning basin for vessels and extending down, and into, the river beyond the outer breakwater. Such breakwaters are costly to build and also costly in maintenance. The turning basin would serve as a very efficient winter refuge for vessels, if ever required, and

Breakwaters necessary.

Turning basin.



Approach Bridge during N.E. breeze, 6th October, 1917.

the wharf at the inner side would serve, during the navigation season, for shipping lumber for bulkheads, etc., to vessels lying at the moorings.

The finished work would therefore consist of working berthage with 30 feet depth at low water alongside, separated from the 30 feet depth at low water in the Bay by 22 miles of estuary with a dredged channel 20 feet deep for the first 7 miles, ½ mile of natural channel varying from 20 to 30 feet, the "Deep Hole" for 5½ more miles, and 9 miles of outer shoals with an irregular channel in which the governing depth is 20½ feet at low water. This would permit of a vessel of 26 feet draught reaching the wharf on one neap tide, provided that it crossed the outer shoal at some time between two hours before and the time of high water. An outward-bound vessel would have to leave the wharf at some time between one hour before, and the time of, high water, in order to find a sufficient depth at the outer shoal to enable it to cross. That is to say, the period of navigation on one tide is limited at neap tides to two hours on the inward and to one hour on the outward journeys.

Period of navigation.

Waiting for tides.

These conditions would, of course, be improved during the time of spring tides, but the governing factor is necessarily the period of high water of neap tides. The question of providing for deeper draught vessels is dealt with in the paragraphs (on pp. 27 and 28) explaining the reasons for Conclusion 6.

Railway working cramped

The railway terminal facilities on the shore would, as already mentioned, be separated from the wharf site by a single line bridge about 3,500 feet long, and the limited space on the island would also seriously handicap the handling of traffic, and, in particular, the working of grain elevators, for which easy access and roomy sidings are essential to efficiency and despatch.

No construction materials in vicinity.

In regard to materials for construction, not only had timber, steel and cement to be imported, but also rock, gravel and sand had to be obtained from a distance. For completion of the works, even on the comparatively small scale of the initial development, rock would have to be brought from a distance of 70 miles, and gravel and sand from 20 miles or so.

CHURCHILL.

Natural protection.

At Churchill, Nature has provided magnificent breakwaters consisting of rocky cliffs rising to heights of from 40 to 70 feet, enclosing a harbour 6 miles in length and from 1 to 2½ miles in width at low water and 1½ to 4 miles at high water.

Entrance to harbour.

The entrance to the harbour consists of a narrow gap between these headlands with a low-water width of 1,600 feet, a width of 850 feet at 30 feet depth and 750 feet of width having depths exceeding 60 feet. Inside the entrance, there exists to-day an area of 140 acres with depths of 30 feet and over at low water, and a further area of about 180 acres with depths varying from 18 to 30 feet at low water, beyond which, as already indicated, there is a vast area of lesser depth.

Storms innocuous.

Owing to the configuration of the cliffs guarding the entrance, as already mentioned in the description of Churchill on page 12, the only gales which affect the inside area are those from directions between north-north-east and east-north-east, and because of the inclination of the inner area to the south-east, the only part effected by such gales is a short strip of shore on the west side of the entrance, where two small bays are clearly the beaches on which waves caused by these gales spend themselves.

Site for wharf.

The obvious site for a wharf is the completely sheltered east side, where it would be situated at a distance of no more than 1½ miles from the deep water of the Bay. It is an ideal site in every way.

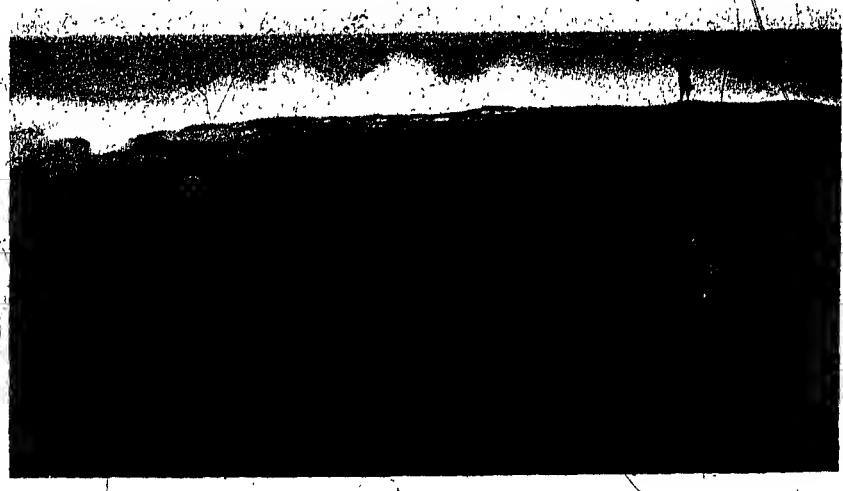
Borings show easy dredging.

Borings taken and trial pits excavated during the past few months disclose the fact that the bed consists of gravel and sand with some clay and some boulders. It is of a nature easily dredged, and through such material it is perfectly simple to dredge a channel 30 feet deep along the wharf front and to connect it by a channel of the same depth, 600 feet wide, to the 30-feet contour depth line at low water inside the harbour. The amount of dredging involved is but little more than a million cubic yards, and if ever extended accommodation is necessary, only a very small amount of further dredging would be required.

Even to make a 40-feet approach to wharves having that depth alongside, the additional dredging would not amount to one and a half million cubic yards.

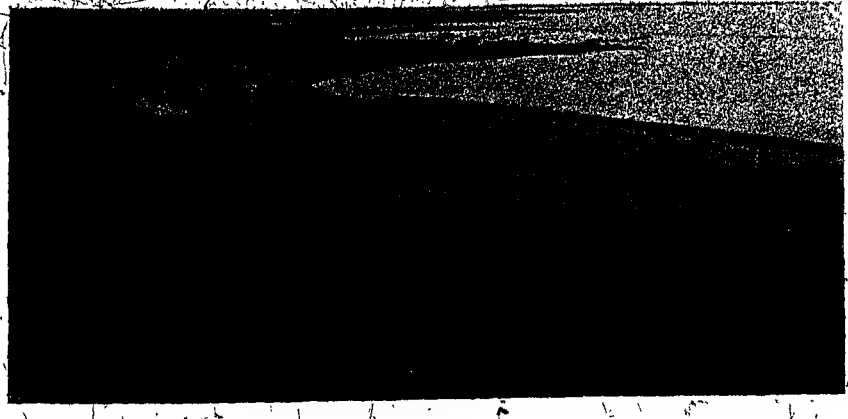
There is a large area of land at a suitable level immediately adjoining the site, on which railway terminal facilities can be provided at relatively small cost. Access to the wharves is easy from the terminal yard, not only

Suitability for railway facilities.



Churchill. Stormy sea outside the cliffs guarding the harbour.

for future working but also for constructional purposes, while access from land to wharf extends over the whole length. There is ample room therefore for dock facilities, transit sheds, grain elevators, railway lines, etc., and for the efficient handling of all traffic.



The smooth water inside the same cliffs at the proposed site for the wharf.

Material for constructional purposes, such as rock, gravel and sand, is obtainable in almost unlimited quantities within a mile of the proposed works.

Construction materials at hand.

Such, then, are the physical conditions pertaining to both Nelson and Churchill upon which, in conjunction with other considerations described later, the decision has unhesitatingly been arrived at, that Churchill is the port

Boring being made on the beach near the proposed wharf site during investigations.

to be selected as affording a real and attractive harbour in which shipping facilities can be provided in calm water protected from all storms by the surrounding cliffs and at a minimum of cost and of time.

CONCLUSION 2.—(CAPITAL COST).

Proposed initial development adequate.

The estimated costs are based upon the initial test development suggested by the Minister, viz., "accommodation in either harbour for "six cargo vessels in port at one time, with working berths for three of the "six, the estimated draught of vessels to be not less than 26 feet." This provision appears to be ample for the purpose, and has been adopted for the plans and estimates included in this report. It is more than sufficient for the shipment of 25 million bushels of grain during a season of 100 working days, and still leaves one berth free for the import and export of general cargo, including the export of cattle.

NELSON.

Works necessary to complete Nelson.

The figures for Nelson are for such works as are necessary to complete the island, to provide a deep-water permanent berth on the outer face thereof and the necessary dock equipment, to dredge a basin 30 feet deep at low water in which vessels can lie afloat at all stages of the tide, to substitute permanent piers for the present crib-piers of the approach bridge, to dredge a course directing the river water to the upper end of the wharf, to dredge a channel from the lower end of the basin to the inner end of the "Deep Hole," and also to construct rock breakwaters on either side of the basin to protect vessels working at the wharves, or lying at moorings, from

storms. Winter berths for craft can be provided inside the breakwaters and adjoining the lighter quay without additional cost. The estimate also includes the provision of such aids to navigation as are considered necessary, even for a "test development," and also an elevator and store house for one million bushels of grain. The working house admits of extension of plant, if, and when, considered necessary, and the store house also can be added to, if and when required.

Item.	Description.	Unit.	Quantity.	Price.	Amount.	Estimated cost.
	Wharf to accommodate 3 ships.			$	$	
1	Cribwork in substructure... ...	c. yd.	130,000	15	1,950,000·00	
2	Concrete in superstructure ...	c. yd.	25,000	20	500,000·00	
3	Gravel fill behind crib and wall...	c. yd.	84,000	3	252,000·00	
4	Earth fill behind crib and wall ...	c. yd.	1,150,000	50 c.	575,000·00	
	Breakwaters.					
1	Cribwork	c. yd.	15,845	15	237,675·00	
2	Concrete	c. yd.	24,760	20	495,200·00	
3	Rock fill on outer breakwater ...	c. yd	230,750	5	1,153,750·00	
4	Rock fill on inner breakwater ...	c. yd.	474,400	4	1,897,600·00	
5	Rock fill in island apron	c. yd.	63,450	4	253,800·00	
	Bridge Pier Cribs.					
1	Concrete in bridge piers	c. yd.	31,500	20	630,000·00	
2	Gravel fill in bridge piers... ...	c. yd.	7,000	3	21,000·00	
3	Removal of old cribwork... ...	c. yd.	31,500	nil.	0·00	
4	Removal of earth fill in crib ...	c. yd	6,000	1	6,000·00	
5	Stone pitching around piers ...	c. yd.	40,000	4	160,000·00	
	Dredging.					
1	Dredging—Dock and Basin ...	c. yd.	3,600,000	1·20	4,320,000·00	
2	Dredging—Channels	c. yd.	2,600,000	1·60	4,160,000·00	
	Aids to Navigation.					
1	Light vessel	—		Lump sum.	107,500·00	
2	Pilot vessel...	—		Lump sum.	85,000·00	
3	Buoy vessel	—		Lump sum.	312,000·00	
4	Beacon towers and lights... ...	each	6	4,000	24,000·00	
5	Cribs for beacon towers	each	5	80,000	400,000·00	
6	Lighted buoys	each	20	3,775	75,500·00	
7	Breakwater head lights	each	2	1,500	3,000·00	
	Dock Equipment.					
1	Transit sheds (3)	c. ft.	2,400,000	10 c.	240,000·00	
2	Piles under shed columns ...	each	153	100	15,300·00	
3	Bollards	each	16	500	8,000·00	
4	Cranes	each	6	30,000	180,000·00	
5	Harbour Master's equipment ...	—		Lump sum.	20,000·00	
6	Offices (equipment only)	—		Lump sum.	5,000·00	
7	Water supply, lighting, drainage, telephones, etc.	—		Lump sum.	250,000·00	
8	Buoys for mooring 3 vessels ...	each	4	1,000	4,000·00	
	Slipway and equipment	—		Lump sum.	275,000·00	
	Grain Elevator	—		Lump sum.	2,000,000·00	
	Railway Lines	l. ft.	20,000	3	60,000·00	
					20,676,325·00	
	Contingencies, including engineering,	10 per cent.		...	2,067,632·00	
				Total ...	$22,743,957·00	

Agreement upon estimates.

The quantities of engineering works have been calculated from the drawings, and the prices are considered fair and reasonable by Mr. McLachlan, who has had unrivalled experience of the cost of works at Nelson. The Aids to Navigation, in regard to both quantity and price, have been settled in consultation with Captain Robinson and Mr. Cody of the Marine Department of the Government of Canada. The cost of the grain elevator and equipment has been arrived at in consultation with Mr. Howe and is based on the cost of similar equipment at other ports.

CHURCHILL.

Works provided for.

The figures for Churchill include the provision of a permanent wharf, with 30 feet depth at low water alongside, and the necessary dock equipment, the dredging of a channel to the wharf 600 feet wide and 30 feet deep from the deep-water area inside the harbour, a grain elevator and work house on the same scale as that included in the Nelson estimate, and a small sum for the few Aids to Navigation necessary at this port. A winter berth for craft is included in the items for Wharf and Dredging.

Item.	Description.	Unit.	Quantity.	Price.	Amount.
				$	$
	Wharf to accommodate 3 ships.				
1	Cribwork in substructure	c. yd.	101,251	12	1,215,012·00
2	Concrete in superstructure	c. yd.	20,000	18	360,000·00
3	Fill behind crib and wall	c. yd.	1,910,000	50 c.	955,000·00
	Dredging.				
1	Dock basin and approach channel	c. yd.	1,150,000	1	1,150,000·00
2	For cribs and winter berths	c. yd	400,000	1	400,000·00
	Aids to Navigation.				
1	Beacon towers and lights	each	2	4,000	8,000·00
2	Entrance head light	each	1	4,000	4,000·00
3	Lighted buoys at entrance	each	2	3,500	7,000·00
	Dock Equipment				
1	Transit sheds (3)	c. ft.	2,400,000	10 c.	240,000·00
2	Bollards	each	16	500	8,000·00
3	Cranes	each	6	30,000	180,000·00
4	Harbour Master's equipment	—	Lump	sum.	10,000·00
5	Offices (equipment only)	—	Lump	sum	5,000·00
6	Water supply, lighting, drainage, telephones, etc.	—	Lump	sum.	250,000·00
7	Buoys for mooring 3 vessels	each	4	1,000	4,000·00
	Slipway and equipment		Lump	sum.	275,000·00
	Grain Elevator	—	Lump	sum.	2,000,000·00
	Railway Lines	l. ft.	25,000	3	75,000·00
					7,146,012·00
	Contingencies, including engineering,		10 per cent.		714,601·00
				Total	$7,860,613·00

Estimated cost.

The same remarks as those following the Nelson estimate apply to the preparation of the figures for Churchill.

The following statement gives a comparison of the estimates of capital costs for both Ports :— Comparison of estimates.

	Nelson.	Churchill.
	$	$
Estimated capital cost of construction works	22,743,957	7,860,613
Interest on capital cost during construction, at Nelson 6 years and at Churchill 3 years	3,411,593	589,546
	26,155,550	8,450,159

Difference in favour of Churchill, on Ports only, $17,705,391,

against which has to be set off the additional capital cost of the railway to Churchill as compared with Nelson, viz., $5,085,000 for 87 extra miles, making the net difference in favour of Churchill on Ports and Railway combined, $12,620,391. The subsequent charges arising from the extra mileage are dealt with in the comparison of annual charges, Conclusion 5 (p. 26).

It will be seen that the estimated cost of the harbour works at Churchill is less than one-third of the expenditure necessary to complete the works at Nelson, and that even including the railway estimates, the figures for Churchill are little more than one-half of the sum required for Nelson.

CONCLUSION 3.—(TIME FOR COMPLETION).

Construction difficulties at Nelson.

The time required for construction has been the subject of much consideration. At Nelson, the governing factor is the dredging, which amounts to 6,200,000 cubic yards. Experience gained during the years 1913–1918 shows that dredging operations are frequently interrupted by rough weather, and disposal of the excavated material is another factor tending to prolong the time. The other engineering works have also to be carried out in an exposed position and in a restricted working area. Materials for some of the works, such as rock, gravel and sand, have to be brought by rail or river from distances varying from 20 to 70 miles, and, as the estimates disclose, the quantities of work to be done at Nelson are greatly in excess of those required at Churchill. It is considered that six years would be the minimum time necessary to carry out the "test development" works at Nelson.

Time for completion at Nelson.

Easy construction at Churchill.

The works at Churchill would be carried out in a sheltered situation. No roughness of weather can sensibly affect the progress of either construction works or dredging. The working area is practically unlimited, and materials, such as rock, gravel and sand, can be obtained in abundance in the immediate neighbourhood. In fact, excepting for climatic reasons, common to both ports, the site at Churchill is ideal. Under these conditions, three years has been assumed as a safe time for the Churchill works, which is one-half of the time which would be required at Nelson.

Time for completion at Churchill.

The length of time which would be occupied in constructing the initial development at either port is described as being "a matter of prime importance." On this requirement there can be no question of the advantage of Churchill.

CONCLUSION 5—(ANNUAL CHARGES).

Annual charges.

The estimate of annual charges shows that, in addition to such costs as apply equally to both ports, considerable extra expenditure is involved at Nelson :—

EXTRA ANNUAL MAINTENANCE COST AT NELSON.

	$	$
Engineering works. *Engineering Works, maintenance.*		
Approach bridge	17,800	
Rock around back of island	12,690	
Rock in breakwaters	152,570	
Dredging	200,000	
Beacon cribs (5)	40,000	
		423,060
Aids to navigation. *Aids to navigation, maintenance and operation*		
Light vessel	18,750	
Pilot vessel	37,500	
Buoy vessel	62,500	
Depreciation and insurance on these three vessels at 3 and 5 per cent. respectively on capital cost of $504,500	40,340	
Lighted buoys (18 extra)	5,625	
Beacon lights (4 extra)	1,250	
Breakwater lights (1 extra)	300	
		166,265
Extra cost at Nelson.		$589,325

Agreement upon annual charges.

The Engineering maintenance charges are from figures prepared by Mr. McLachlan, and the Maintenance and Operation charges in regard to Aids to Navigation, by Captain Robinson and Mr. Cody, based on St. Lawrence River costs, plus 25 per cent. Both are considered reasonable.

Capital charges.

For the purpose of estimating the capital charges, a sum representing 5 per cent. interest has been added to the estimated capital cost of construction of both Nelson and Churchill, as shown on page 25, but, in addition, Churchill must be charged with :—

(1) Interest on extra cost of railway, and

(2) Cost of maintaining and operating 87 additional miles of railway

In respect of (1) and (2), the figures are taken from the report of Mr. C. S. Gzowski, Chief Engineer for Construction, Canadian National Railways.

The following summary gives the result of these calculations :— Annual charges.

ANNUAL CHARGES.

	NELSON. $	CHURCHILL. $
Harbour Works.		
Interest charges on extra Capital cost, $17,705,391—at 5 per cent.	885,269	
Extra cost of maintenance already detailed	589,325	
Railway Works.		
From mile 356·8.		
Interest charges on extra Capital cost of 87 additional miles, viz., $5,085,000—at 5 per cent.		254,250*
Maintenance of extra mileage ..		69,600*
Extra station		4,000*
Operating 100 mixed trains over 87 additional miles		29,580*
Operating 130 grain trains (10,000,000 bushels) over same additional mileage		56,550*
	$1,474,594	413,980

Net Annual difference in favour of Churchill, $1,060,614.

Nothing has been included in this statement for the extra cost, which would be bound to arise, in handling grain and other cargo over a long single line approach, and in landing and loading cargoes over the restricted area of the "island" at Nelson, but even excluding these disadvantages, the value of which it is difficult to assess, there is a clear saving of over a million dollars per annum in adopting Churchill as the terminal port. Heavier cost of operating Nelson.

CONCLUSION 6—(ROOM FOR EXTENSIONS).

NELSON.

In regard to the capacity of the two sites for "such progressive "extension as future requirements might dictate," the "island" site at Nelson was originally intended for development to accommodate 10 vessels at the wharves. The present proposed scheme can also be extended to accommodate 10 vessels at the wharves and 10 more vessels at mooring berths. Further extensions can be made if necessary. This wharf, whether in its initial or extended stage, would be limited by the nature of the proposed approach Suitability for extensions. Limitation of draught.

* Figures taken from Mr. Gzowski's Report.

channel to vessels of 26 feet draught. To improve this channel so as to admit vessels of 28 feet draught would involve further dredging between the wharf and the "Deep Hole," involving the removal of about 1¾ million cubic yards of material at a cost, including contingencies and engineering charges, of $3,000,000, or thereabouts. To provide for greater draught than 28 feet would necessitate dredging a channel 1,000 feet wide through the outer shoal over a distance exceeding 9 miles in length, on which dredgers would have to be operated practically out at sea, where the nearest land, and this standing only very little above high-water level, is 5 to 8 miles away to the west. Having regard to the nature of the material to be removed and also the exposed position, the cost of dredging would be prohibitive, and by "prohibitive" is meant a cost exceeding 50 millions of dollars. Therefore, for all practical purposes, Nelson, as a port, is limited at neap tides, to vessels of 26 feet draught, with the works included in the estimate, to 28 feet draught with a further expenditure of $3,000,000, and, beyond this draught, it is limited for all time.

Dredging over outer shoal impracticable.

CHURCHILL.

Ample depths at Churchill.

At Churchill, vessels of 30 feet draught can enter the harbour along the easier course already mentioned at all states of the tide while, for 12 hours of each day, even at neap tides, 36-feet vessels would have ample depth of water. On the alternative course, vessels of 35 feet can enter at all states of the tide, and for 12 hours of each day there would be sufficient water for vessels of 40 feet draught. At spring tides the conditions, of course, would be even better.

Draught practically unlimited.

Inside the harbour the works covered by the estimates allow of the passage to the wharf of 28-feet draught vessels at all states of the tide, and the harbour bed can be readily dredged at reasonable cost to any depth required.

No real limits to extension.

The site of the wharf has been so laid out as to admit of easy and, for all practical purposes, unlimited extension along the east shore of the harbour. Certainly 20 vessels could be berthed in one straight line, with moorings for 20 more, and this does not by any means exhaust the possibilities of extension. Because of the nature of the site and the availability of material, the cost of extensions at Churchill would always be far less than at Nelson. Nature has already provided magnificent and indestructible breakwaters, while at Nelson any extension of the wharves would necessitate extending the outer breakwater too.

Extension less costly.

While both sites admit of considerable extension, it is clear that, in regard to both time and cost, the advantage lies with Churchill, where there is no practical limit either to the length of wharf which can be built or to the draught of vessels which can be accommodated.

CONCLUSION 7—(ICE CONDITIONS).

Lack of reliable data.

It is unfortunate that no data exist on which any reliable opinion can be arrived at in regard to ice conditions at either, or both, of the Ports. The information available, extending over a number of years, is almost entirely confined to that given in the Journals of the Hudson's Bay Company's establishments on the Hayes River (York Factory) and at Churchill, and it is not surprising to find that the notes in these Journals are in no wise an indication as to the dates of the opening and closing of the rivers for navigation by ocean-going vessels. The Company's supply vessels generally arrived so late in the season that there was but little risk of finding the approaches blocked with ice, and these vessels almost invariably left in ample time to avoid any chance of being frozen in.

There was no reason, therefore, to keep accurate records of facts which scarcely concerned the traders at the factories—no interest in noting the earliest date on which a vessel might freely enter, or the latest date on which departure must be made—and the notes in the Journals are practically confined to events and conditions as they occurred at, and in the immediate vicinity of, the establishments. There are no entries of journeys made over the many miles separating the factories from the river entrances, in order to observe and record the opening and closing to navigation, and there can be but little doubt that no such observations were ever made.

Alleged dates of opening and closing.

The records of the Geological Survey of Canada, 1879–80, however, contain a table purporting to give "dates of opening and closing of Hayes River at York Factory compiled from authentic records"—the opening and closing of the river at the factory, and not the opening and closing of ocean navigation. The only "authentic records" from which this information can have been taken are, in the main, those kept at the factory. They extend over too long a period, 1828 to 1880, to have come within the personal knowledge of any one observer, and therefore it is a fair inference that the compilation is, to all intents and purposes, based on inspection of the actual Journals. It should be noted, too, that the entries at York Factory refer to the comparatively small Hayes River at that factory, and not to the very much greater Nelson River at Port Nelson.

Extracts from Hudson's Bay Company's Journals.

The Hudson's Bay Company have kindly furnished a few actual extracts from the York Factory Journals as recorded over several of the years between 1719 and 1850, but, unfortunately, only six of the years given correspond with those included in the geological survey report referred to. The following table shows how these extracts compare with the definite dates of opening and closing contained in that report, in regard to these six years:—

ICE CONDITIONS.

Extracts from Survey Report and Journal. Year.	Dates given in Geological Survey Report.	Extracts from Journals.
1829	Closed 11th November	Oct. 18th. "Considerable quantities of ice drifting "in the river." (No note regarding date of freeze up.).
1830	Opened 17th May ...	April 25th: "The river appears to be on the move "above, as we hear the ice passing underneath the "ice before the fort."
		May 11th: "The channel on the opposite shore "appears to have opened. The ice came down in "heavy masses and blocked up on the opposite "shore."
		May 18th: "The drift ice from above came down "rapidly and collected about us until about ½ past "5 this morning, when it took its departure nearly "to Point of Marsh with a velocity equal to the "descent of a heavy waterfall."
1839	Closed 19th November	Oct 15th: "River is driving full of ice."
		Nov. 9th: "River driving full of ice."
		Nov. 17th: "Fine mild weather, river is still open."
		Nov. 24th: "Sharp weather. The river took with "ice opposite the establishment."
1840	Opened 12th May ...	May 21st: "The river broke up nearly opposite 10/- "Creek, but shortly after stopped"
		May 23rd: "Ice cleared out to Point of Marsh."
1849	Closed 27th November	Nov 1st: "Much ice continues to drift on the river."
		Nov. 13th: "Scarcely any ice drifting in the river."
		Nov. 27th: "In course of last night the river abreast "of the factory was frozen over."
1850	Opened 31st May ...	May 20th: "The ice upon the river observed to be "broken to the point above the factory."
		May 28th "The ice on the south side of the river "broke up as far as French Creek, but still remaining "fast on the north side from the first point beyond "the factory seawards."
		June 1st: "In course of last night the barriers of "crushed ice above the factory began to break up, "and the river is now open along the northern shore "down, to the old factory. Very little ice is left on "the north shore, but the southern side and the "island are thickly covered"
		June 5th: "The river is still packed full of ice between "the factory island and the south shore."

"Report dates" for Nelson mainly conjectural.

It will be seen that in only two of these six instances—the opening in 1830 and the closing in 1849—do the dates appear to coincide. The notes in the extracts are clearly not intended to give definite dates of opening and closing to ocean navigation, and it seems correct to assume that the dates in the Report referring to Nelson are mainly conjectural, even when confined to the waters opposite the Hudson's Bay Company's Factory and the Hayes River. They become, at best, only guesses—perhaps intelligent guesses—at definite dates, when applied to opening and closing to ocean navigation.

Dates for Churchill also uncertain.

Precisely the same remarks apply to such definite dates as have been recorded in regard to Churchill. In so far as the facts recorded in the Journals can be held to apply to navigation—and this must only be to an extremely small extent—the definite dates given of opening and closing cannot be strictly, or even closely, established.

Effect of shore ice.

At all events, these dates cannot, even remotely, be connected with conditions in the Bay, where shore ice extends outwards for several miles from land. It is probable that the opening of navigation to ocean-going vessels is governed more by shore ice along the coast of the Bay than by ice within the rivers. It is reasonable to suppose that when this shore ice begins to break up, there is a general tendency to drift southwards with the Bay currents, but it is always subject to wind influences. With north-easterly breezes it packs upon the shore, and drifts away from the shore during winds from the opposite direction, but the general tendency must be southward.

Ocean-going vessels.

There are far too few data to enable any definite conclusions to be drawn, and such scanty records as do exist in the Hudson's Bay Company's Journals afford no real criterion—no real guidance—in regard to navigation to either port by ocean-going vessels.

No reliable decision possible.

It was for these reasons that in the preliminary Report the opinion was recorded that—

> "The evidence regarding ice conditions at both ports is vague
> "and inconclusive, and no satisfactory or reliable decision can be
> "given in regard thereto."

And, since that view was expressed, no new facts have come to light on which it would be possible to formulate any other statement. It is therefore still impossible to say that either port is open to ocean-going steamers for a longer or shorter period than the other.

III.—Table of Comparison.

Summary of comparison.

The following summary gives a comparison of the factors relating to both Nelson and Churchill which affect their suitability as terminal ports :—

	Nelson.	Churchill.
Accommodation proposed for initial development	3 berths at wharf, 3 berths at moorings	3 berths at wharf, 3 berths at moorings.
Navigation.		
Accessibility for vessels—		
(*a*) Distance from open sea to centre of wharf	22 miles	1½ miles.
(*b*) Entrance to port	9 miles from, and out of sight of, nearest land	Direct from deep water to harbour.
(*c*) Distance, in broken lengths, over which, after "initial development" works are completed, navigation is governed by —		
Depths of 20 feet	5½ miles	Nil.
Depths of over 20 feet and up to 30 feet	11 miles	Nil.
Ample depths (all at low water spring tides)	5½ miles	The whole.
(*d*) Rise of tide above low water of spring tides—		
At entrance to port—		
Spring tides	17 feet	15 feet.
Neap tides	13½ feet	10½ feet.
At wharf site—		
Spring tides	15 feet	15 feet.
Neap tides	10½ feet	10½ feet.
Aids to navigation required	Light ship Pilot vessel Buoy vessel 6 beacons 20 gas buoys 2 breakwater head-lights	3 beacons. 2 gas buoys.

	Nelson.	Churchill.
Pilotage	Necessary	Unnecessary.
Exposure to storms	Protected only by 20 miles of shoal water	Immune.
Limiting draught of vessels—		
(*a*) After "initial development"	26 feet	28 feet.
(*b*) Ultimate maximum	28 feet	40 feet (or more).
Works.		
Construction works in "initial development"—		
(*a*) Estimated cost—		
Harbour works, including interest during construction	$26,155,550	$8,450,159.
Railway from mile 356·8	$2,458,000	$7,543,000.
(*b*) Time required to complete works	6 years	3 years.
(*c*) Material such as rock, gravel and sand	From 20 to 70 miles distant	Adjacent.
(*d*) Access for construction	Over single line bridge 3,500 feet long	Direct from railway yard.
(*e*) Lay-out of works	On restricted area of island	On shore alongside, and unlimited area
Working conditions.		
(*a*) Railway haul on imports and exports	87 miles less than at Churchill	
(*b*) Annual charges (including extra haul)		$1,060,614 less than at Nelson.
(*c*) Approach from railway terminal	Over single line bridge 3,500 feet long	Direct from terminal yard.
(*d*) Space for working at wharves.	Very restricted	Unlimited.

Recommendation.

Essential factors.

These are the conditions constituting the essential factors in the past, at the present time and in the future, at Nelson and Churchill. In so far as they relate to physical characteristics, they represent indisputable facts and, in regard to capital cost, running cost, and time required for construction, the figures are based on careful estimates agreed with the Government Departmental officials concerned and are believed to be fair and reasonable. At all events, they are strictly comparable.

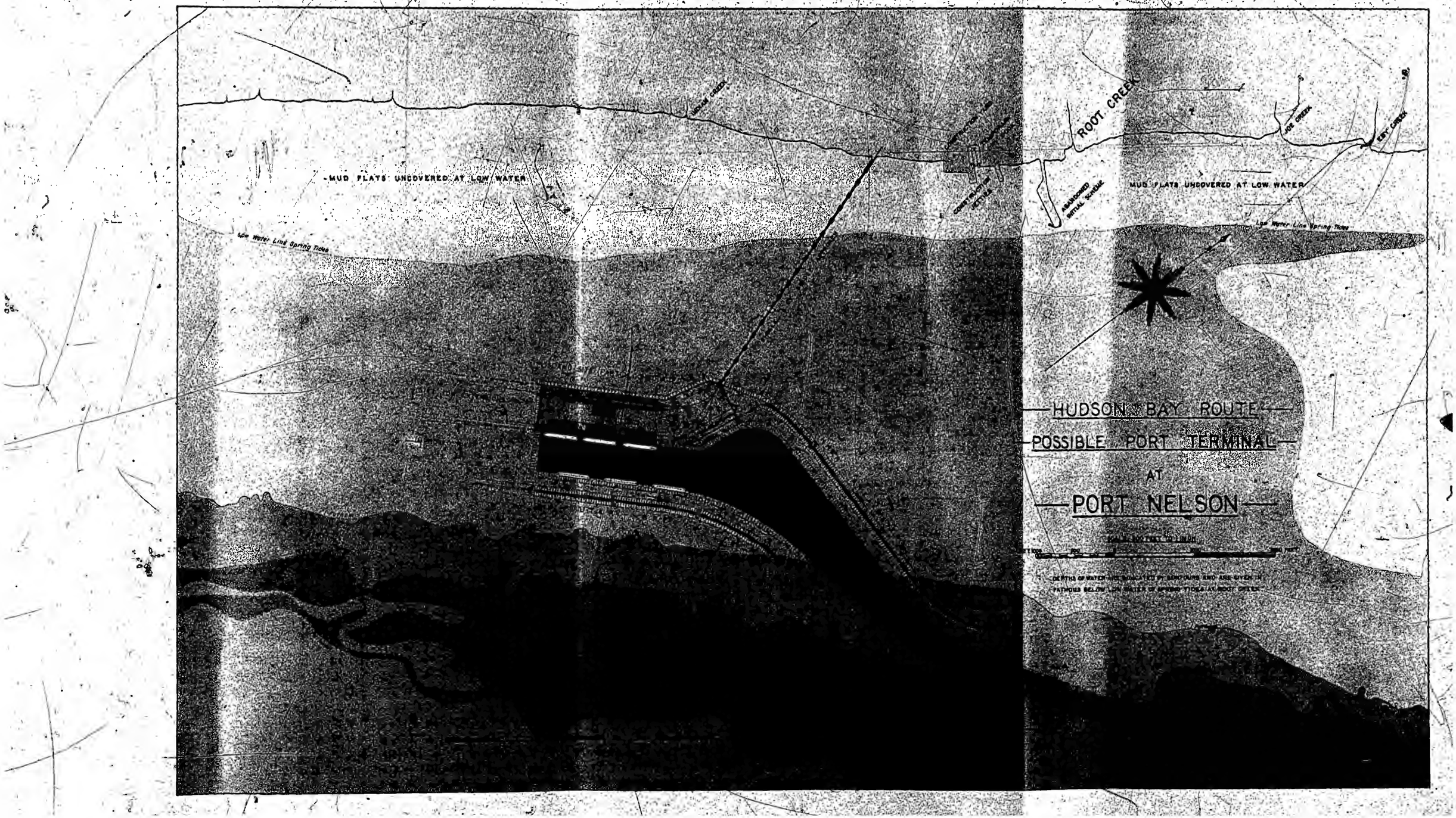
A study of the above Table of Comparison cannot but lead to the conclusion that Churchill is in every respect save one—the extra cost and annual charges imposed for all time by 87 additional miles of railway—in every other respect, incomparably superior to Nelson. In fact, so marked were the advantages, as shown by drawings and charts and by a careful examination of all the data available, that it was felt there must be some other and overwhelming reason for the selection of Nelson.

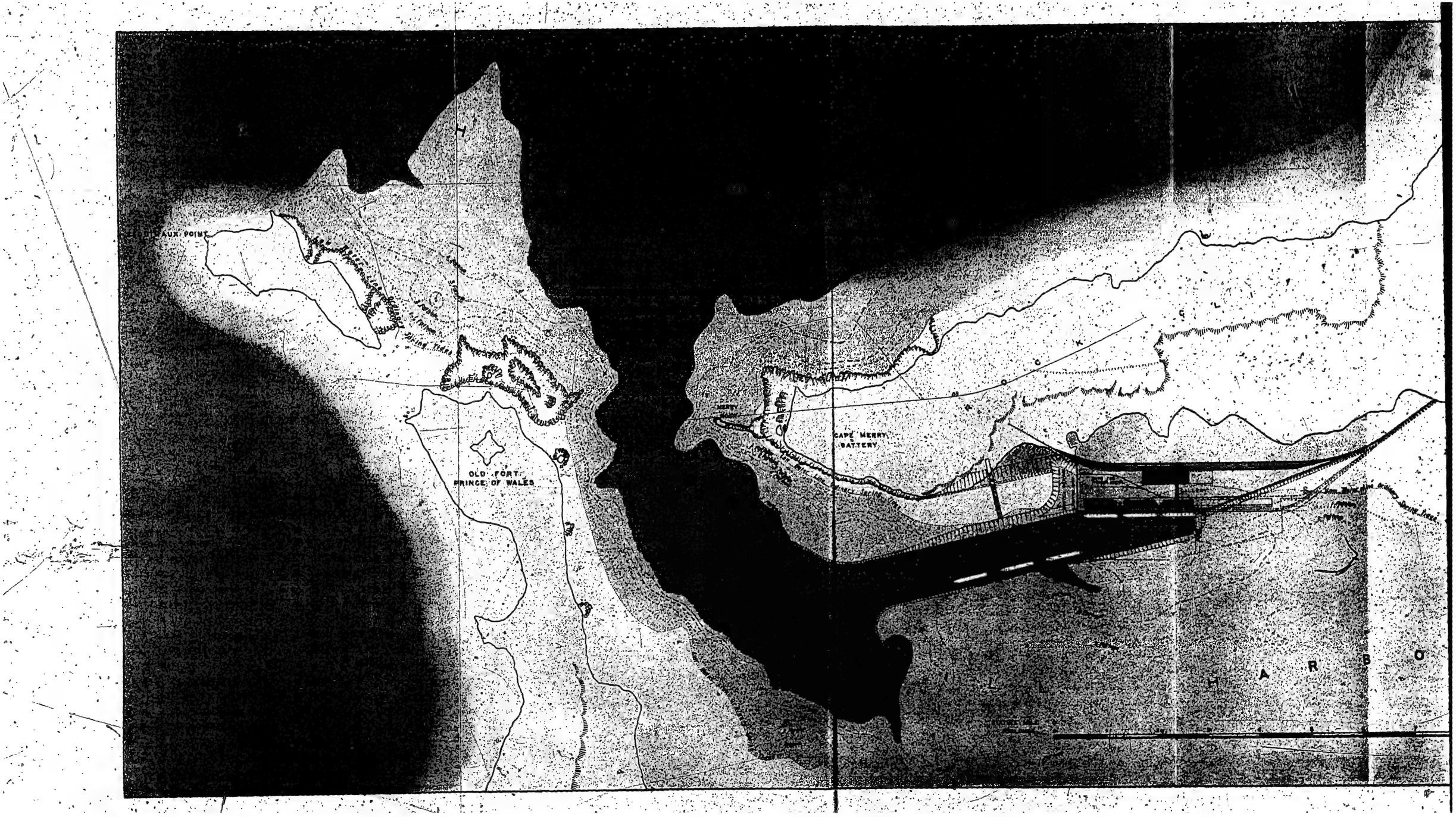
Early impressions unfounded.

It had been stated, more than once, that at Churchill the area of land available for terminal development was very restricted and expensive to improve; that the area available for docks was very small and, to increase this area, the basin would practically all have to be dredged out; and every indication that this dredging would have to be done in solid rock. The investigations, however, made in the spring of this year as to the nature of the harbour bed, and the inspection of the site in August last showed, beyond doubt, how misleading, how unfounded, were these statements. The land area in the immediate neighbourhood of the proposed wharf is far in excess of any probable requirements and can be developed at relatively small cost; the area available for docks is practically unlimited and the dredging of the basin involves no large expenditure; while the bogey of "solid rock" is completely dispelled by the borings recently put down, as described in Appendix "C."

Churchill recommended.

The foregoing Report is believed to have dealt with all determinable questions of a relevant nature. Notwithstanding the predisposition of the Government towards Nelson, the facts concerning physical conditions, the estimates of cost and the time required for construction are overwhelmingly in favour of the selection of Churchill as the terminal port for the Hudson Bay Railway, and it is recommended that the works commenced at Port Nelson should not be proceeded with, and that Churchill should be selected for the Hudson Bay Port.


MUD FLATS UNCOVERED AT LOW WATER
60m Water Line Spring Tides
ROOT CREEK
ABANDONED INITIAL SCHEME
MUD FLATS UNCOVERED AT LOW WATER
Low Water Line Spring Tides
HUDSON BAY ROUTE
POSSIBLE PORT TERMINAL
AT
PORT NELSON


OLD FORT
PRINCE OF WALES
CAPE MERRY
BATTERY
H A R B O

U D S O

ROCK CLIFF

CAPE MERRY BATTERY

MERRY ROCK

ENTRANCE TO HARBOUR

LD FORT
CE OF WALES

CHURCHILL HARBOUR

FOR EXTENSIONS

—HUDSON BAY ROUTE—

—POSSIBLE PORT TERMINAL—

AT

—CHURCHILL—

SCALE 600 FEET TO 1 INCH

FEET 600 0 600 1200 1800 2400 3000 FEET

DEPTHS OF WATER ARE INDICATED BY CONTOURS AND ARE GIVEN IN FATHOMS BELOW LOW WATER OF ORDINARY SPRING TIDES OR 7½ FEET BELOW HIGHEST POINT ON MERRY ROCK AT ENTRANCE TO HARBOUR

STATUTE MILE 0 1
FURLONGS 0 1 2 3 4 5 6 7 8 STATUTE MILE FURLONGS

APPENDICES.

APPENDIX A.

OFFICE OF
THE MINISTER OF RAILWAYS AND CANALS,
OTTAWA, CANADA.

January 5th, 1927.

DEAR MR. PALMER,

In order that we may have record of the understandings reached as a result of our several conferences, I beg to advise you as follows :—

In 1911 the Canadian Government commenced the construction of a railway to Hudson Bay. In 1912, in order that the road might be placed completely under contract, it became necessary for the Government of the day to make immediate choice between the only two possible ports on the west coast—Nelson and Churchill. After a personal visit to both places by the then Minister, and consideration of the information available at the time, the Minister, on the advice of his engineering staff, recommended the establishment of the railway terminus at Nelson, and plans for harbour terminals were prepared by an engineer specially selected and sent to Nelson for that purpose. Upon consideration of the scheme of development then suggested differences of opinion arose, and the engineer resigned his appointment. A member of the departmental engineering staff was then assigned the task of preparing suitable plans, as a result of which the present scheme of development at Nelson was approved and actively prosecuted by the department during 1914 and the succeeding years, until the fall of 1917, when the work was discontinued owing to war conditions. During the following winter the construction of the railway was also discontinued upon completion of the bridge at the Kettle Rapids crossing of the Nelson River, about 92 miles from Port Nelson.

On the railway $15,245,889 had been expended to March 31, 1926, and on the Nelson terminals $6,242,114.

At the present time that portion of the railway previously constructed is being reconditioned and it is planned to continue the construction of the railway in 1927. This imposes upon the Government early consideration of the question of harbour development in order that the Hudson Bay route may be assured fair trial as an ocean outlet for Western grain and cattle, and for such other traffic in agricultural, mineral, forest and manufactured products as may develop.

Controversy has always existed as to the relative merits of Nelson and Churchill as the Bay terminus, and notwithstanding the selection of Nelson in 1912-13, controversy has persisted. In 1920, a special Committee of the Senate was appointed to examine and report upon the Hudson Bay project generally, and upon the character of the ports and their fitness for terminals. Upon the evidence then adduced, the Committee reached the following conclusion upon the harbour phase of the project:—

> "That in the opinion of this Committee sufficient care was not
> "taken in the selection of Nelson as the terminus of the railway, and
> "that the Government should not make further important expenditures
> "upon this port without first making a new and thorough examination
> "into the relative merits of Churchill and Nelson as a terminus for
> "the railroad."

In view of the substantial expenditure already incurred at Nelson, and the shorter rail haul to that point, the Government is naturally predisposed towards Nelson, but desires, above all things, that the port chosen, and its arrangements, should afford the best possible opportunity for the development of trade through the Bay.

The problem of harbour development in the two places differs very widely and, as regards Churchill, the use of that port would involve the construction, maintenance and operation of about 90 additional miles of railway. As to the suitability of the terrain between the Nelson and the Churchill rivers to railway construction, we hope to have definite information in the course of the next few months. Should the survey now being made disclose conditions unfavourable to railway construction, this would, of course, dispose of any question as to Churchill, but if a railway is found practicable, we will require your advice concerning Churchill also. If that port should be found to be capable of such early and economic development as would afford better and safer facilities than Nelson, and more readily available, that would be a factor of great importance to the successful development of the Hudson Bay route. For these reasons we think it unwise and not in the interests of Canada to restrict your investigation to the port of Nelson only, unless, meanwhile, Churchill should be eliminated for railway reasons.

In the event of Churchill becoming a possibility, we should have, in addition to relative costs of construction and maintenance, a comparative estimate of the length of time necessary to provide terminals at either port sufficient to enable a proper test of the route to be made. We consider this element of time a matter of prime importance.

We want, also, your opinion of the design of the existing works at Nelson, and as to whether any change could be made there which would either reduce the cost or the length of time required for development, or improve conditions in any way at that point.

What we have in mind as an initial test development—and this is suggested more for your guidance than as a conclusive and limiting instruction—would be the provision of accommodation in either harbour for six cargo ships in port at one time, with working berths for three of the six, the estimated draught of vessels to be not less than 26 feet. The minimum development projected at each port should, of course, be capable of such progressive extension as future requirements might dictate.

If a railway to Churchill be found practicable, we desire that your report should cover a possible development at both Nelson and Churchill, with estimated cost, your recommendation as to the choice to be made and reasons therefor.

In outlining, in this general way, the matters upon which the Government desires your advice, it is not intended to ask you to consider problems unconnected with port development. We appreciate that, owing to climatic conditions, it will not be possible for you to conduct your personal examination of Nelson and Churchill before next summer. We shall, however, do everything in our power to facilitate your work at both points and would be glad to have your conclusions as soon as possible thereafter, as we are anxious to avoid delay in the prosecution of this important undertaking.

Faithfully yours,

(Signed) CHAS. A. DUNNING

FREDERICK PALMER, Esq., M.Inst.C.E.,
Rendel, Palmer & Tritton,
12–15, Dartmouth Street,
Westminster,
London.

APPENDIX B.

OTTAWA,
24th August, 1927.

HON. CHAS. A. DUNNING,
Minister of Railways and Canals,
Ottawa, Canada.

SIR,

HUDSON BAY TERMINAL PORT.

I am submitting herewith a preliminary report recording the conclusions I have come to regarding the factors governing the choice of a terminal harbour for the Hudson Bay Railway.

The conclusions are based on investigations carried out during the past few months, and upon my recent personal visit to the Ports of Nelson and Churchill. A full report dealing with the subject in detail will follow as soon as possible.

I am, Sir,

Your obedient Servant,

(Signed) F. PALMER.

OTTAWA,
24th August, 1927.

HUDSON BAY PORT.

PRELIMINARY REPORT.

This report is submitted in order that the Government may know as early as possible the results of the investigations made in regard to the selection between Nelson and Churchill of a terminal port for the Hudson Bay Railway.

The "initial test development" suggested in the Minister's letter of 5th January, 1927, is as follows:—

(1) Working berths for three vessels of 26 feet draught,
(2) Moorings for three more similar vessels,

and it is also prescribed that the site be suitable for extensions.

In the conclusions given later, this suggested initial development, being considered sufficient, has been adopted, and suitability of site for extension taken as a basic condition.

NELSON.

The Port of Nelson is a roadstead in the estuary of the river of that name. It is open to the Bay and exposed to gales from the north-east, which occur at somewhat frequent intervals during the period of navigation. The work done so far consists of preparing an island site at which a wharf can be built, and nothing of a permanent nature exists to-day beyond the superstructure of a bridge, about 3,500 feet long, leading from the west shore to the island, which constitutes the site referred to. It may be mentioned here that the site selected for the works, and the method proposed for providing a wharf afford as satisfactory a scheme for a Port on this river as can be devised.

The island is situated 22 miles up the estuary from the 30 feet depth contour in the Bay. An irregular shoal extends from mile 19 to mile 13½ (5½ miles) over which the governing depth is 20½ feet. From mile 13 to 7½ a deep channel or hole exists with depths varying from 24 to 94 feet. From mile 7½ to mile 3½ the governing depth is 18 feet and from mile 3½ to the downstream end of the wharf a channel is proposed to be cut through depths varying from 18 feet at the lower end to about 2 feet at the wharf. The proposed channel, which is intended to be 300 feet wide and 20 feet deep, will therefore entail dredging not only from the wharf to mile 3½ but also to mile 7½.

The rise of tide above the spring tide low-water level ranges from 17 feet at spring tides to 13½ feet at neap tides at mile 19, while at the wharf the range is from 15 feet at spring tides to 10 feet at neap tides, and high water at mile 19 occurs 40 minutes earlier than at the wharf. Vessels of 26 feet draught entering the river at neap tides would, in order to cross the shoals referred to, have to pass mile 19 at some time between two hours before, and the time of high water whereas outward bound vessels of this draught would, in order to have sufficient depth of water over the outer shoal at mile 19, have to leave the wharf at some time between one hour before, and the time of high water. That is to say, the period of navigation on one tide for 26 feet vessels is limited at neap tides to two hours on the inward and one hour on the outward journeys.

At the wharf, the intention was to provide a depth of 30 feet so that vessels might lie afloat at all stages of the tide. The finished works would therefore consist of working berthage 30 feet deep separated from the 30 feet depth in the Bay by 22 miles of estuary with a dredged channel 7½ miles long and an outer shoal 5½ miles long. By largely increasing the depth in the dredged channel, to give 24 instead of 20 feet, it would be possible to bring a vessel of 28 feet draught to and from the wharf during periods limited to an hour at the entrance for incoming and to an hour at the wharf for outgoing vessels. Beyond this draught it would be impossible to bring a vessel into the Port on neap tides excepting at prohibitive cost in dredging. The depths referred to are below low water of ordinary spring tides and the navigational depths are those at high water of neap tides. These are the depths which constitute the controlling factor although at high water of spring tides, conditions of course are more favourable.

Being so exposed to north-easterly gales it would be absolutely necessary to protect vessels lying in the deep area at the wharf by breakwaters.

Rock, gravel and sand for constructional purposes would have to be obtained from distances of from 20 to 70 miles.

The railway terminal facilities on the shore would be separated from the wharf site by a single line bridge about 3,500 feet long and the limited space on the island would also seriously handicap the working of grain elevators.

CHURCHILL.

At Churchill, Nature has provided magnificent breakwaters, consisting of rocky cliffs rising to heights of from 40 to 70 feet, and the entrance to the harbour consists of a narrow gap between these headlands with a low-water width of 1,600 feet, a width of 850 feet at 30 feet depth and 750 feet of width having depths of over 60 feet.

Owing to the position of the entrance, the only gales which affect the Bay inside are those from the north-east and as the Bay inclines to the south-east the only part affected by such gales is a short strip of coast on the west side of the entrance. The rest of the Bay is quite unaffected by gales from any direction.

Inside the entrance there exists to-day an area of about 140 acres with depths of 30 feet and over and a further area of about 180 acres with depths varying from 18 to 30 feet. Beyond this there is a vast area of lesser depth.

The obvious site for a wharf is the completely sheltered east side where it would be situated at a distance of no more than 1¼ miles from the deep water outside the entrance. Borings taken during the past few months on this site disclose the fact that the bed consists of gravel and sand with some clay and some boulders. It is of a nature easily dredged and the proposal is to form a depth of 30 feet at the wharf connected with the 30 feet depth inside the entrance by a short channel 600 feet wide of the same depth. The extent of dredging necessary to afford a not less than 30 feet depth, at low water, throughout is but little more than a million cubic yards.

Rock, gravel and sand for constructional purposes can be obtained in almost unlimited quantities within a mile of the proposed works.

There is a large area of land at a suitable level immediately adjoining the site at which railway terminal facilities can be provided at relatively small cost.

CONCLUSIONS.

With these brief descriptive remarks the conclusions come to can be given. They are:—

1. That Churchill is undoubtedly the Port to be selected as affording a real harbour in which shipping facilities can be provided in calm water protected from all storms by the surrounding rocky cliffs.

2. The estimated costs of corresponding accommodation at Nelson and Churchill disclose marked advantage in favour of the latter, the figures showing that, including interest during the period of construction, the cost at Churchill will be less than one-third of what is required to complete Nelson. Even after adding the cost of the extra 87 miles of railway to Churchill, the cost at this place will be only about one-half of the Nelson port estimate.

3. The time for completion of the works at Churchill, viz., 3 years, is one-half of the time needed to carry out the Nelson works.

4. That Churchill provides a completely sheltered port for shipping from the moment the entrance is passed, while at Nelson no shelter can be confidently reckoned upon until the wharf is reached, and then only by the provision of breakwaters.

5. That the annual charges, including interest, operation and maintenance would be about a million dollars greater at Nelson than at Churchill.

6. That at both Nelson and Churchill the sites admit of considerable extensions, but at much less cost at Churchill than at

Nelson. The wharf, either in its initial or extended stage, would at Nelson be governed by the limiting nature of its approach, to vessels of 26 feet draught during a brief period around high water at neap tides unless much increased expenditure is incurred in dredging. It is limited to a draught of 28 feet even after this dredging is done unless still further expenditure of a prohibitive character is undertaken. At Churchill the accommodation proposed will, in the "initial development," admit of 28 feet draught vessels during the 24 hours of each day while for extensions there is no practical limit to the draught of vessels which can be provided for.

7. The evidence regarding ice conditions at both ports is vague and inconclusive and no satisfactory or reliable decision can be given in regard thereto. It has been stated that the river at Churchill freezes over earlier than the Nelson river and, also, that Bay ice blocks the entrance to Nelson for a later period than that over which Churchill entrance is closed; but in the absence of any evidence dealing directly with the navigation aspect of the question, it is impossible to say that either port is open to ocean-going steamers for a longer or shorter period than the other.

Following upon these conclusions, it is strongly recommended that Churchill be made the port terminal for the Hudson Bay Railway because it affords by far the best possible opportunity for the development of trade through the Bay.

APPENDIX C.

Description of Boreholes Sunk at Churchill Harbour.

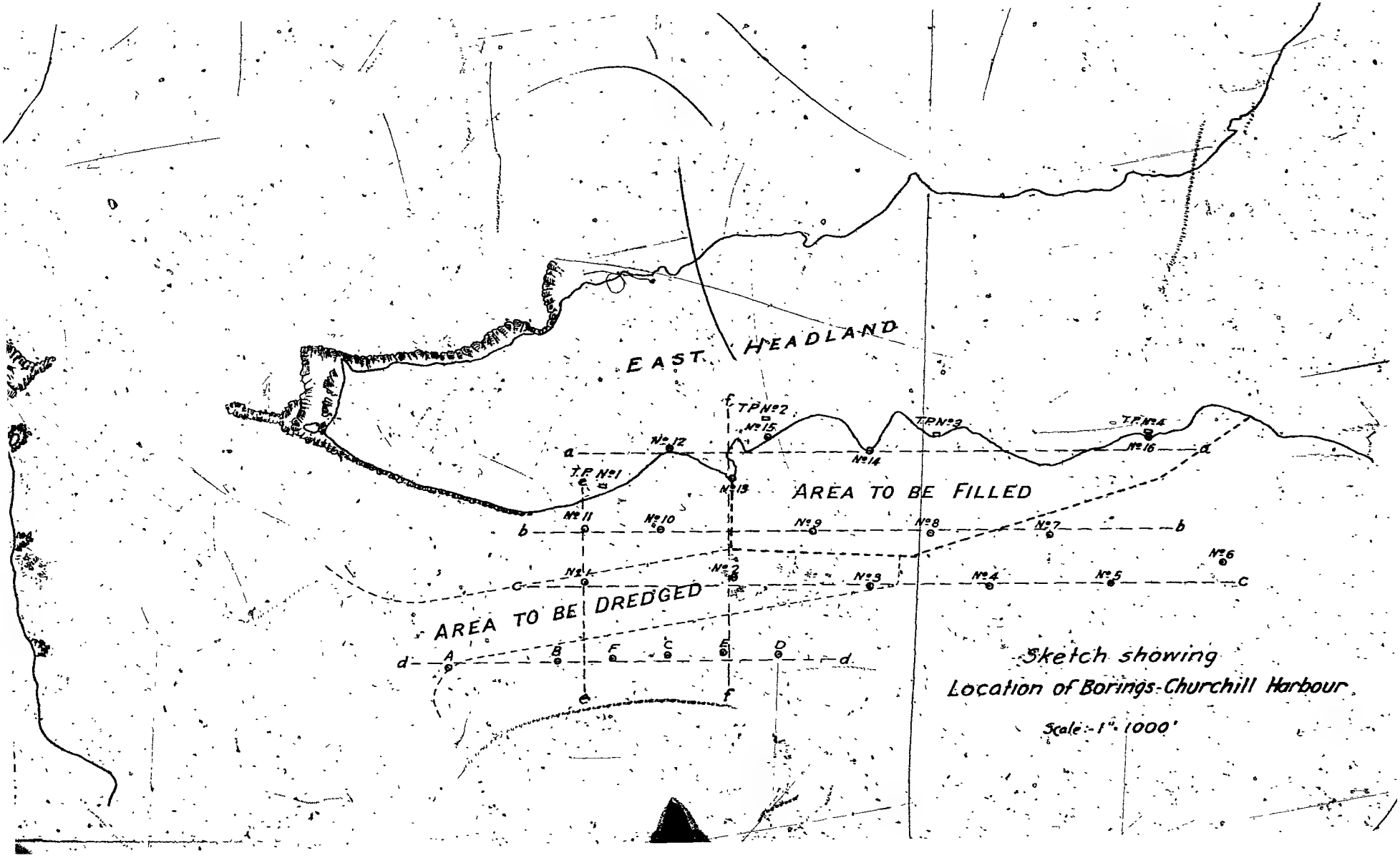
The borings shown in the accompanying sketches were sunk on and around the proposed site during the months of April to July, 1927, Bores Nos. 1 to 15 being drilled by a Dicks Well Drill, and Bores A to F with a Wash Boring Outfit. The boreholes over the water area were taken from the ice before the break-up. In all cases, along the shore, boulders were encountered and had to be shattered by dynamite; fewer boulders, however, were met with in sinking over the water area, and these occurred with less frequency as the distance from the shore increased.

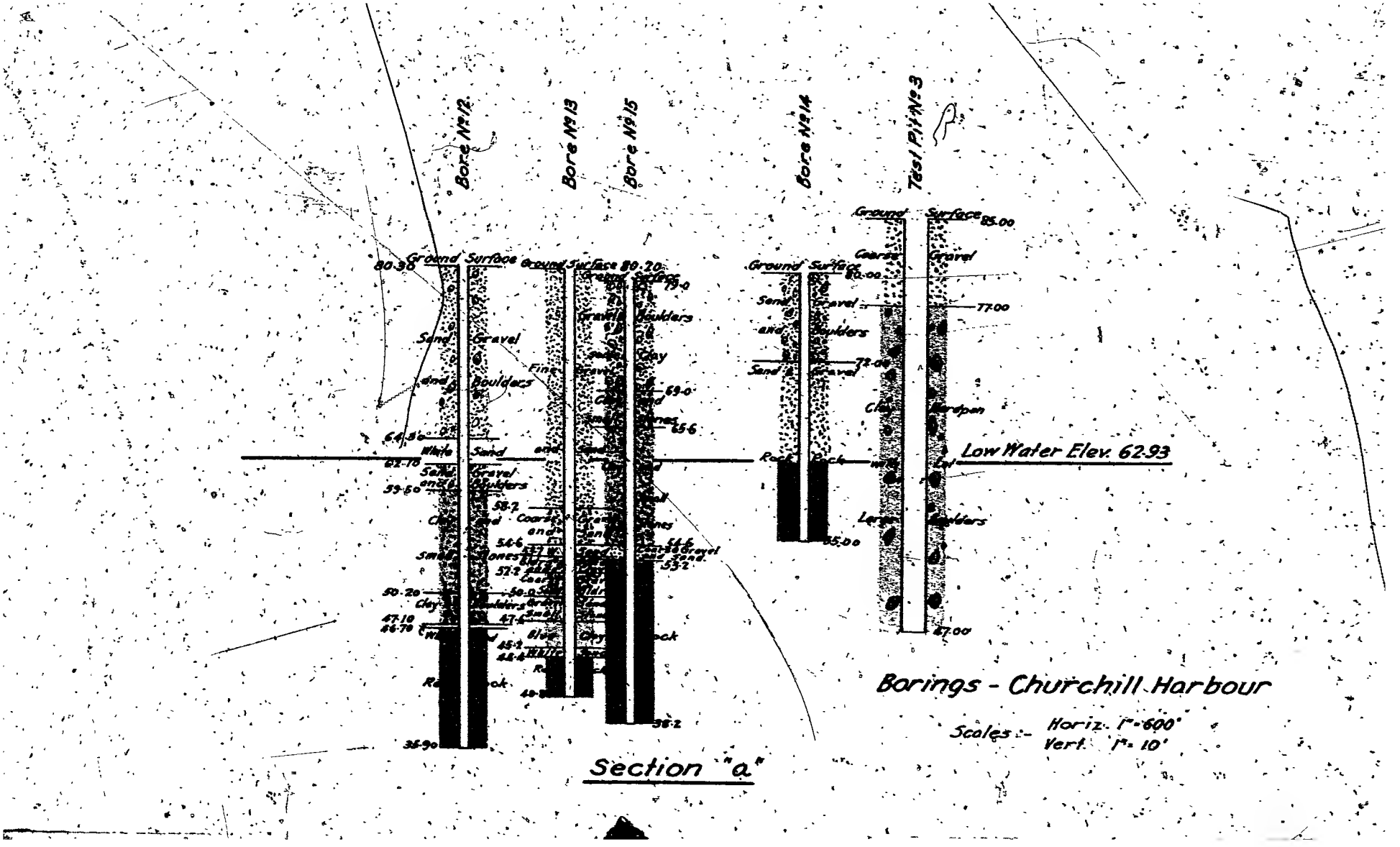
The bores indicate that the rock, which outcrops in the cliffs of the headlands, dips down beneath the shore and harbour bottom, its depth beneath the harbour bed increasing with the distance from the shore. Above the rock, within the bored area, occur strata of various sands, gravel, and small stones with some clay and some boulders.

The proposed dredging, to be carried out to a depth of 30 feet below Low Water Ordinary Spring Tides, will therefore be entirely in sand and gravel, with occasional soft clay and probably some boulders, as seen on bores Nos. 1 to 3, and A to F. To increase the depth for 36 feet and even for 40 feet draught vessels, at L.W.O.S.T., would only mean dredging deeper through similar material. The future extension of the wharf, as shown on the works plan, would likewise only necessitate further dredging in gravel, sand and soft clay, with occasional boulders, for all draughts of vessels up to 40 feet, as indicated by bores Nos. 4, 5 and 6. The dredging also proposed for the Winter Berths and Lighter Quay, to be carried out to a depth of probably 20 feet below L.W.O.S.T., will be in material corresponding to the above, as shown by bores Nos. 10 and 13.

A summing-up of the information yielded by the boreholes reveals the fact that the whole of the dredging to be performed, both under the present scheme and its possible future extensions, will be carried out in material which is easily dredged.

In addition to the boreholes, four test or trial pits were dug on the shore, in the position indicated on the Location Plan by T.P. Nos. 1 to 4, and these confirmed the evidence of the boreholes as to the general formation of the Harbour.

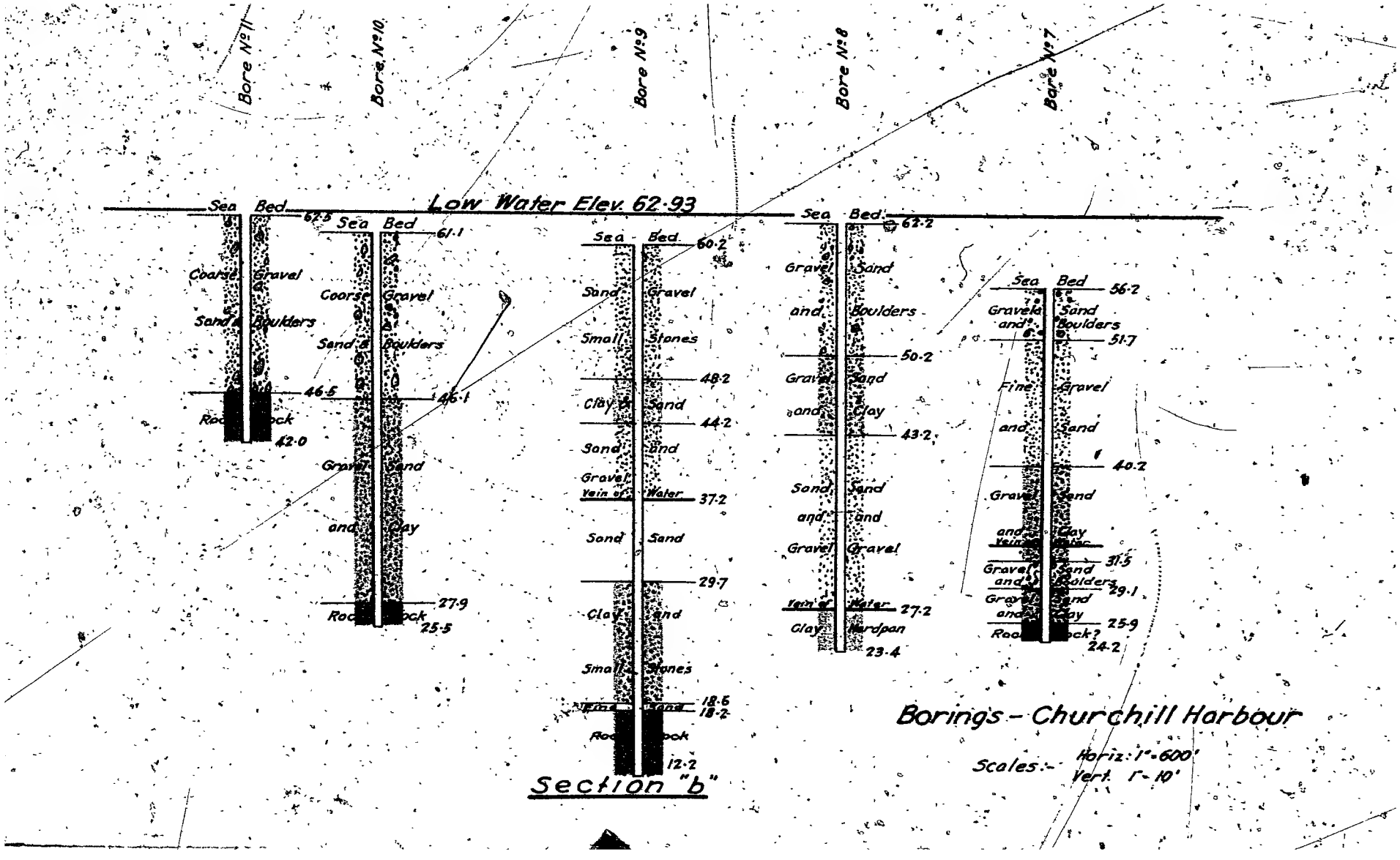

EAST HEADLAND
T.P No 1
T.P No 2
T.P No 3
T.P No 4
No 1
No 2
No 3
No 4
No 5
No 6
No 7
No 8
No 9
No 10
No 11
No 12
No 13
No 14
No 15
No 16
AREA TO BE FILLED
AREA TO BE DREDGED
A
B
F
C
E
D
a
b
c
d
e
f
Sketch showing
Location of Borings-Churchill Harbour
Scale:-1" 1000'

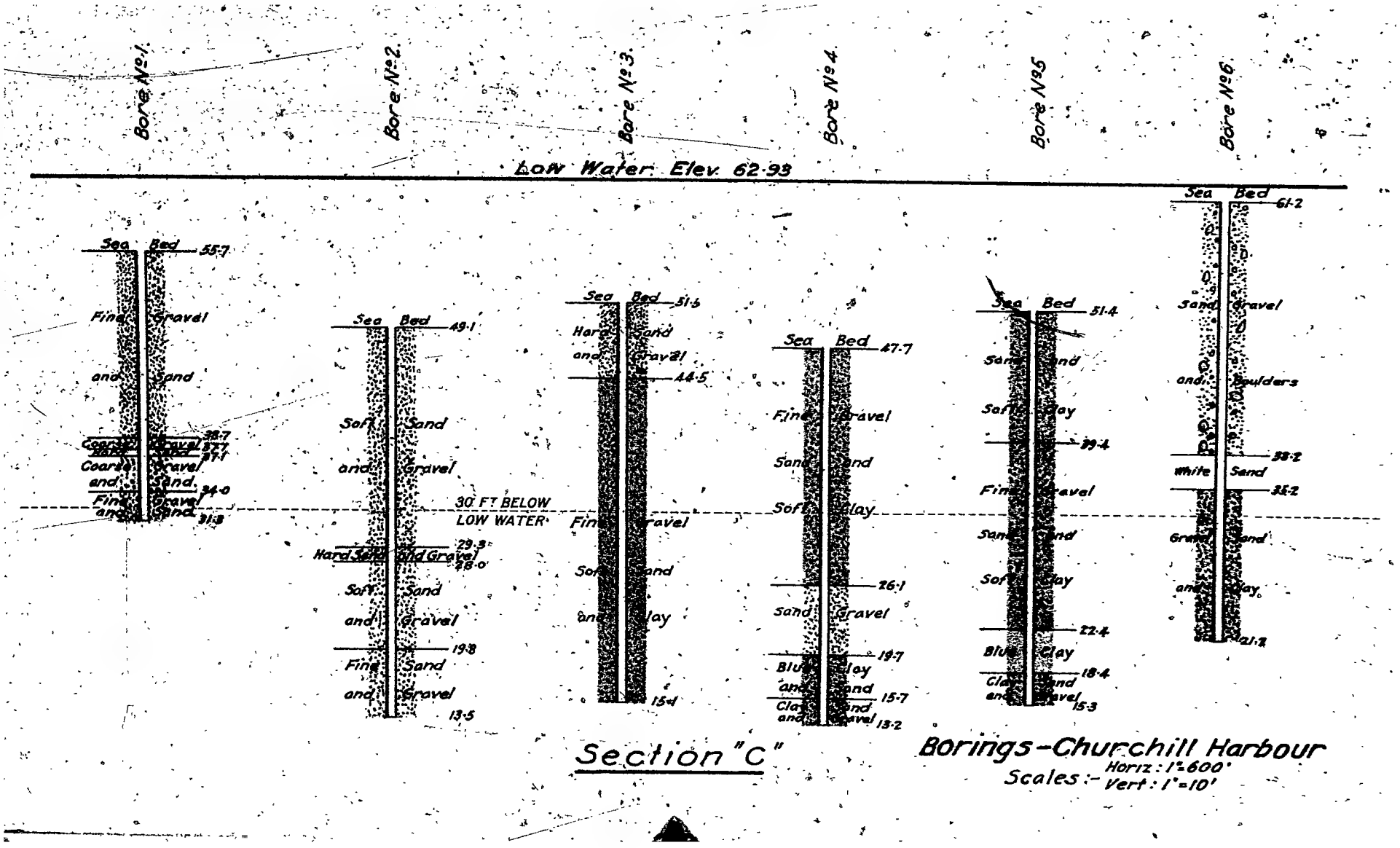


Section "a"

Borings - Churchill Harbour

Scales :- Horiz. 1" = 600'
Vert. 1" = 10'

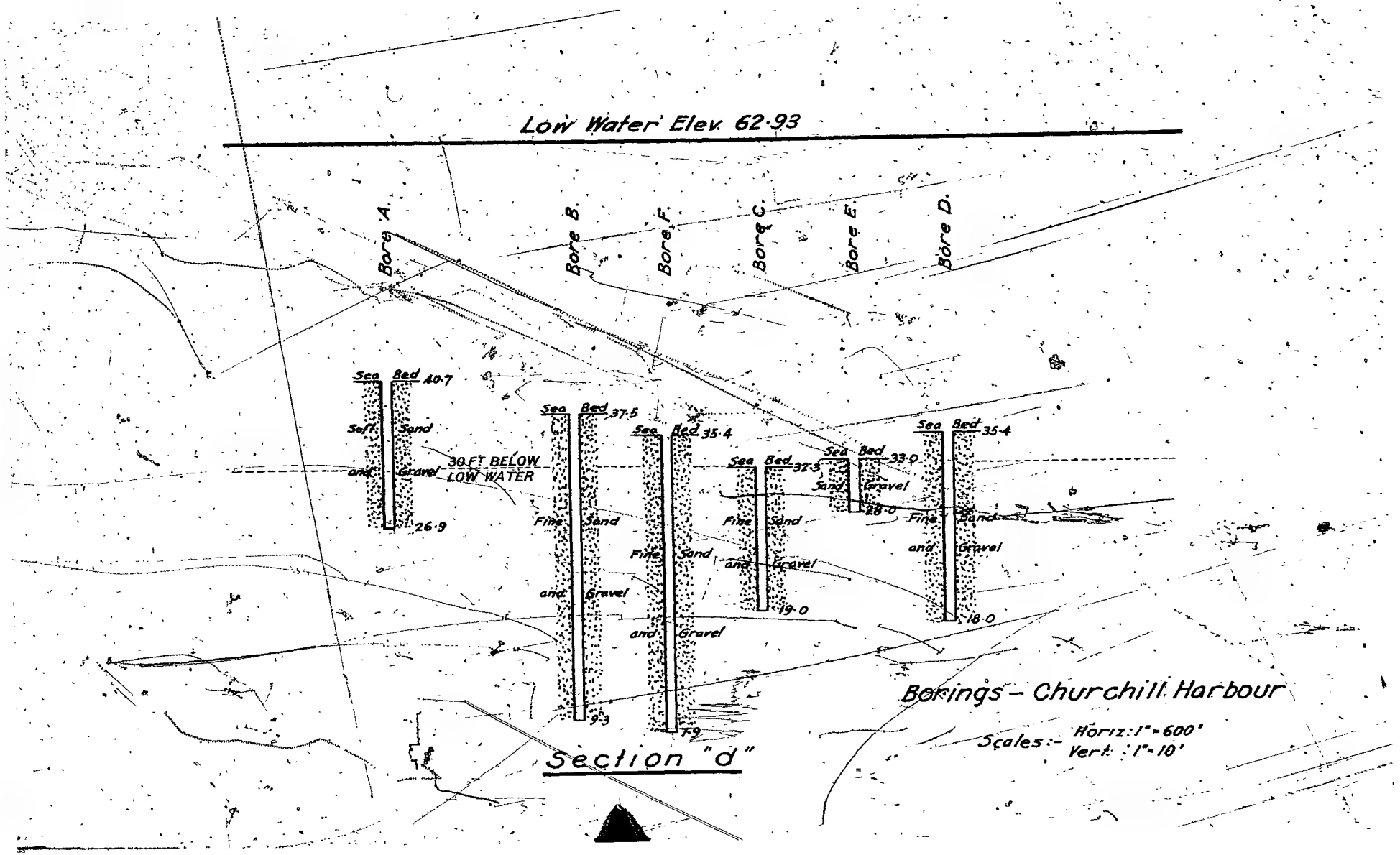

Bore No 11
Bore No 10
Bore No 9
Bore No 8
Bore No 7
Low Water Elev. 62·93
Sea Bed 62·5
Coarse Gravel
Sand & Boulders
46·6
Rock
42·0
Sea Bed 61·1
Coarse Gravel
Sand & Boulders
46·1
Gravel Sand
and Clay
27·9
Rock
25·5
Sea Bed 60·2
Sand Gravel
Small Stones
48·2
Clay & Sand
44·2
Sand Sand
Gravel Vein of Water
37·2
Sand Sand
29·7
Clay Sand
Small Stones
18·5
18·2
Rock
12·2
Sea Bed 62·2
Gravel Sand
and Boulders
50·2
Gravel Sand
and Clay
43·2
Sand Sand
and and
Gravel Gravel
Vein of Water
27·2
Clay Hardpan
23·4
Sea Bed 56·2
Gravel and Sand Boulders
51·7
Fine Gravel
and Sand
40·2
Gravel Sand
and Clay
Vein
31·5
Gravel and Sand Boulders
29·1
Gravel and Clay
25·9
Rock?
24·2
Section "b"
Borings – Churchill Harbour
Scales:- Horiz: 1"=600'
Vert. 1"=10'

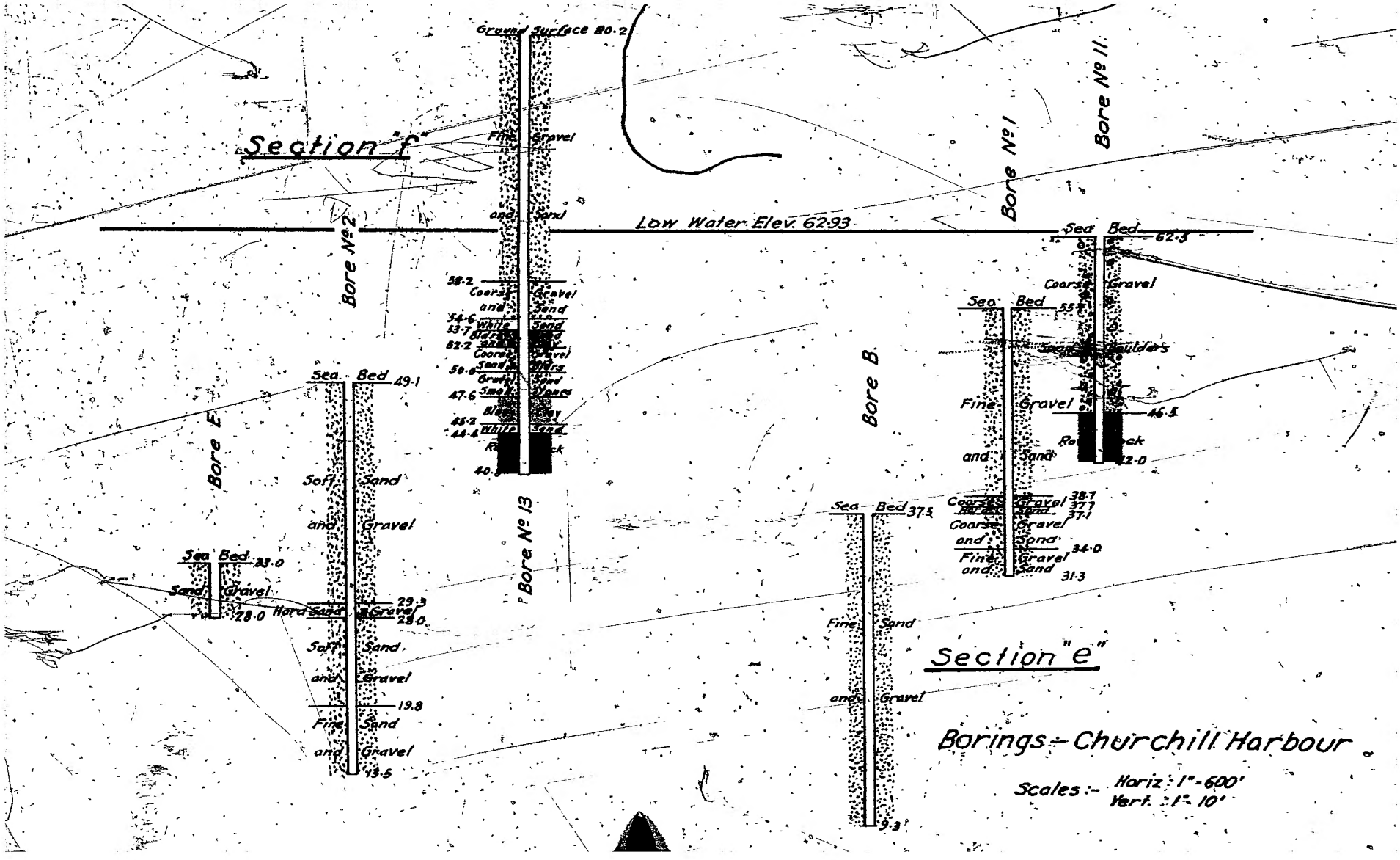


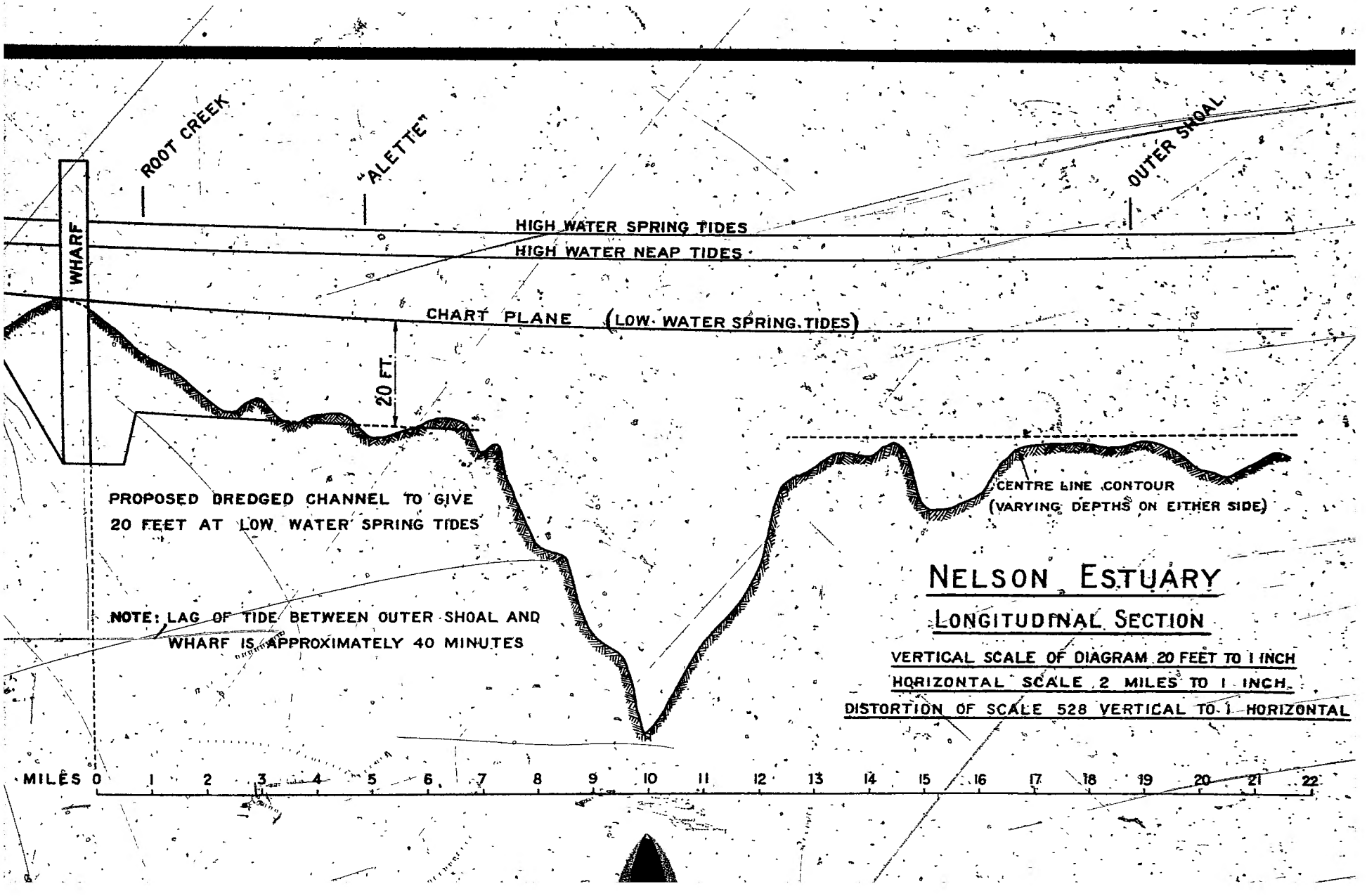
Section "C"

Borings – Churchill Harbour

Scales :- Horiz : 1"=600'
Vert : 1"=10'


Low Water Elev. 62·93
Bore A.
Bore B.
Bore F.
Bore C.
Bore E.
Bore D.
Sea Bed 40·7
Soft Sand and Gravel
26·9
30 FT BELOW LOW WATER
Sea Bed 37·5
Fine Sand and Gravel
9·3
Sea Bed 35·4
Fine Sand and Gravel
7·9
Sea Bed 32·3
Fine Sand and Gravel
19·0
Sea Bed 33·0
Sand Gravel
28·0
Sea Bed 35·4
Fine Sand and Gravel
18·0
Section "d"
Borings – Churchill Harbour
Scales :- Horiz: 1" = 600'
Vert : 1" = 10'


Section "f"
Ground Surface 80.2
Fine Gravel and Sand
Low Water Elev. 62.93
Bore No 2
Bore No 13
Bore No 1
Bore No 11
Bore B
Bore E
Sea Bed 62.3
Coarse Gravel
Sea Bed 55.1
Boulders
Fine Gravel and Sand
46.5
12.0
Sea Bed 37.5
Coarse Gravel and Sand 38.7
Coarse Gravel and Sand 37.7
Coarse Gravel and Sand 37.1
Fine Gravel and Sand 34.0
31.3
Fine Sand and Gravel
9.3
Sea Bed 49.1
Soft Sand and Gravel
29.3
28.0
19.8
Fine Sand and Gravel
13.5
Sea Bed 33.0
Sand Gravel
Hard Sand & Gravel
28.0
Section "e"
Borings - Churchill Harbour
Scales :- Horiz. 1" = 600'
Vert. 1" = 10'



NELSON ESTUARY

LONGITUDINAL SECTION

VERTICAL SCALE OF DIAGRAM 20 FEET TO 1 INCH

HORIZONTAL SCALE 2 MILES TO 1 INCH.

DISTORTION OF SCALE 528 VERTICAL TO 1 HORIZONTAL